nulistice 2018

NATIONAL UNIVERSITY OF LESOTHO

PROCEEDINGS

National University of Lesotho International Science, Technology and Innovation Conference & Expo (NULISTICE)

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Editor-in-chief
Professor Himanshu Narayan
Co-Editors
Dr Mosotho George
Dr Sissay Mekbib

Editor-in-chief

Himanshu Narayan (Ph.D.)
Department of Physics & Electronics, National University of Lesotho

Co-Editors

Mosotho George (Ph.D.)
Department of Chemistry & Chemical Technology, National University of Lesotho

Sissay Mekbib (Ph.D.)
Department of Biology, National University of Lesotho

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Proceedings of the First

NATIONAL UNIVERSITY OF LESOTHO INTERNATIONAL SCIENCE, TECHNOLOGY AND INNOVATION CONFERENCE & EXPO

Maseru, Lesotho
(NULISTICE 2018)

23rd to 26th January 2018
'Manthabiseng Convention Centre

Foreword

Prof. Nqosa L. Mahao
Vice-Chancellor, National University of Lesotho

In the month of January this year, the National University of Lesotho successfully hosted the National University of Lesotho International Science, Technology & Innovation Conference & Expo, NULISTICE 2018. NULISTICE 2018 was the first ever international conference in Lesotho that was primarily focused on Science and Technology-based research. Alongside NULISTICE, the second Renewable Energy Research & Innovation Symposium, RERIS 2018, was also hosted.

Given its position as the only public university in Lesotho, the National University of Lesotho is also the only institution that focuses on research-based education, especially in the fields of science and technology in the country. NUL has engaged itself not only in pure scientific and technological research but is committed to also address some challenging contemporary societal issues.

Last year, the University participated in the successful development of the Solar-Thermal Roadmap for Lesotho in partnership with Bethel Business and Community Development Centre (BBCDC) under the SOLTRAIN project funded by Austrian Development Agency.

Recently, an Energy Research Centre, or ERC, was also established to deal with the crucial issues of energy. Funded by the Africa-EU Renewable Energy Cooperation Programme (RECP), a series of week-long short-courses on various aspects of sustainable energy were successfully offered throughout the year. A number of participants, primarily from the corporate and public sectors, benefitted from this training exercise. From the encouraging feedback received from them, the ERC is now going to start a Master's Programme in Sustainable Energy under the Department of Physics & Electronics.

A Low-Cost Flat Plate Solar Energy Collector developed at NUL won the BIE*-Cosmos Prize at Expo 2017 for "Future Energy" in Astana, Kazakhstan. Precisely one year back in September 2016, the same project had won the Second prize at International Conference on Solar Technologies & Hybrid Mini Grids to improve energy access held at Bad-Hersfeld, Germany.

Very soon NUL is going to establish the Water Institute also to address the water related issues and research in the country. The proposal has already been approved by the University's governing bodies, the Senate and Council. Another important proposal to start the School of Engineering has already been tabled for stakeholders' consultations.

Apart from these training activities and technological research, a number of researchers at NUL have focused mainly on basic science research. They have been working at par with their global peers in some topical areas, such as nanotechnology, energy-materials, etc. For example, cheaper methods have been proposed for the treatment of wastewater under sunlight using nanocomposites that were synthesized here at NUL. Investigations on nano-materials for potential applications of their electrochemical properties in energy efficient devices, production of bio-gas from algae and many other interesting and relevant research-projects have been undertaken by various groups in the University. They have been publishing their findings regularly in journals of international repute and their works have been frequently cited by a number of researchers from all over the world.

Recently, the University has also managed to convert some of its projects into business. NUL is gradually, but very certainly, becoming a brand. A number of products developed at the University have either already hit the market, or are in a process of being launched. The AfriQuartz and Lefika stones; Sebabatso yogurt, fresh and sour milk; Bohlale biscuits; Mashimi wine; Mohalalitoe soaps; and Pius XII automatic egg incubator are just to name some of them. The ability to produce such commodities locally would definitely moderate the over-dependence of Lesotho on neighbouring countries.

The resounding success of NULISTICE is still visible months after. A definite change in perception of the outside world about the University has been experienced. Inside the University, the success has helped boost the morale and self-esteem of staff members. For its future use as reference and for records, it is my pleasure to release the Proceedings of NULISTICE2018.

* Bureau International des Expositions

NATIONAL UNIVERSITY OF LESOTHO INTERNATIONAL SCIENCE, TECHNOLOGY AND INNOVATION CONFERENCE & EXPO (NULISTICE) 2018

In the recent global economic meltdown of 2008, Lesotho as a small nation experienced a serious decline in the job market for graduates. This posed a serious challenge to the National University of Lesotho to respond to this 'national crisis' as declared by His Majesty King Letsie III, the Head of State, who is also the Chancellor of the University. Following this, the University shifted its research focus from purely basic to the applied, innovative and impactful research that addresses the economic challenges of society. It is in this pursuit that the University held two Science and Technology Research and Innovation Expos in 2015 and 2016 showcasing 60, and 180 projects, respectively, that had potential of driving entrepreneurship in the community and hence, stimulating economic growth for thousands of graduates who would otherwise be lost into poverty. These two expos also exposed the need to infuse international views and expertise; and thus, the idea of hosting an international conference originated. This 2018 NUL International Science, Technology and Innovation Conference & Expo is meant to provide an opportunity to turn ideas into action. It is expected that the attending scholars from all over the world will share their basic research findings, lessons in university-industry cooperation, successes and failures in commercialization and policy recommendations in any of the thematic areas mentioned here.

NULSITICE 2018 Thematic Areas:

- Biotechnology and food safety
- Environment and natural resource management
- Agriculture and climate change
- Entrepreneurship and information technology
- Materials science and nanotechnology

A beautiful drone view of the conference venue 'Manthabiseng Conention Centre, Maseru

Photo by: Dr. Dirk Steuerwald

NULISTICE-RERIS2018 Group Photo

Photo by: Mr. Thapelo K. Sephiri

The Core Organizing Committee with the Hon. Ministers

[L to R: Dr. Mosotho George, Mr. Niklas Hayek, Vice-Chancellor Prof. Nqosa Mahao, Hon. Min. of Education Mr. Mokhele Moletsane, Hon. Min. of Comm. Sci. & Tech. Mr. Joang Molapo, Pro Vice-Chancellor Prof. Manthoto M. Lephoto, Prof. Himanshu Narayan and Dr. Thimothy Thamae]

Photo by: Mr. Thapelo K. Sephiri

Welcome Remarks

Prof. Manthoto H. Lephoto
Pro-Vice-Chancellor, National University of Lesotho
& Chairperson of the NULISTICE 2018

It is a great pleasure and honour to welcome you to this auspicious occasion of the NUL International Science and Technology Innovation Conference and Expo (NULISTICE) 2018, featuring the second edition of the Africa-EU Renewable Energy Research & Innovation Symposium (RERIS) 2018. Innovative ideas through research and technology have emerged over the past two decades in a multidisciplinary approach to solve the problems of society and create jobs in the global economic agenda across all sectors. Sustainable use of resources with responsible entrepreneurship action represents a significant advance in understanding how innovation and business practices can help improve living standards of the society. Such a result is more predictable in its positive sense that the business environment between innovator, researcher and entrepreneur has to be supported by flexible policies to encourage all stakeholders to hold them accountable to reasonable standards and to be more creative for societal benefit. This joint conference offers an opportunity to turn ideas into action. It is our collective duty to promote responsible business practices by mobilizing resources and assisting entrepreneurship actions in each sector to ensure self-employment and job creation amongst the youth to develop our nation and continents. One of the key messages to be conveyed here is that responsibility cannot be outsourced. We have to develop flexible policies that would help in promoting ideas and give confidence and support to those who want to build the future. Entering into business means taking responsibility to adopt sustainable business practices that take into account both the bottom line and the impact of their activities on society. Academia, governments and civil society organizations have the responsibility to improve and provide a forum for dialogue, peer learning, standard setting, analysis, and best policy recommendations to promote the innovative practices in Lesotho, the African continent, and the world in general. We hope that such a joint international conference and expo on science, technology and innovation will allow us to take joint actions to assist the youth in our respective countries to bring positive changes in societal development and protect the environment.

We wish you an enjoyable stay in the Mountain Kingdom of Lesotho!

Closing Remarks

His Majesty King Letsie the III of Lesotho
Chancellor, National University of Lesotho

It is my pleasure to join you for this Gala Dinner which also marks the closing of NULISTICE Conference and RERIS Symposium.

During the past two-and-a-half days, we had the opportunity to witness and listen to the presentations and discussions from eminent scientists and experts, not only from the region but also from other countries.

It was extremely satisfying to note that a number of academicians and researchers representing institutions from within the country, especially from the host National University of Lesotho, also took part and presented their interesting findings to the world. I believe they were, by no means any less than their peers, in terms of the quality of work. It clearly shows that even under severe limitations and adverse conditions, the fire of passion to do something original and to create something innovative, keeps burning non-stop. This never-say-no attitude of our scientists is highly commendable.

Yesterday, I had been to the NULISTICE Expo at Pioneer Mall. It was extremely heart-warming to meet so many young innovators and future entrepreneurs, and witness their talent and enthusiasm. I believe that they just need a launching-pad and some support to take off to their promising fortunes. Congratulations to National University of Lesotho for successfully bringing together all these small efforts that eventually summed up into this mega event of NULISTICE 2018.

The University deserves applause for a number of other activities too. As recently as last year, they successfully launched an Energy Research Centre and pushed the proposed Water Institute up to the stage of implementation. Another proposal to establish a School of Engineering is also passing through various stages of approval and we hope to see it materialize into reality pretty soon. These are examples that clearly show that the University in moving in positive direction.

I am aware of the involvement of NUL in a number of projects of national and societal interests. Last year, in partnership with other agencies, they developed the Solar-Thermal Roadmap for Lesotho. Their activities in the areas of energy production, utilization and management, such as running short training courses in the areas of sustainable energy and related issues, and starting a M.Sc. Sustainable Energy programme, are relevant not only for the region, but also globally. It is a matter of great pleasure and satisfaction that one of the projects, namely the Low-Cost Flat Plate Solar Energy Collector, won second and first prizes in Germany and Kazakhstan, respectively, against a number of other international entries.

A number of projects running at NUL have been converted into successful businesses. Sebabatso yogurt is one of the products that originated from the University and is now winning hearts out in the market. Similarly, products like Bohlale biscuits, Mashimi wine, Mohalalitoe soaps, AfriQuartz and Lefika stones, and Pius XII automatic egg incubators, were all born inside NUL laboratories. Many of them have already started challenging similar commodities from other regional manufacturers in the market, and the others are being fine-tuned to see light of the day.

Apart from these, NUL continues to be the only institution in Lesotho that is engaged in some serious, hard-core research in the advanced areas of basic science and technology. We have already had some glimpses of these investigations in the presentations during last two-and-a-half days. Sometimes it seems hard to believe that scientists from such a small country have managed to keep pace with rest of the world over the years, in terms of cutting-edge research in some very current topics, such as, nano-science and nanotechnology, energy-materials and graphene-research, etc. But their work speaks for itself and the rest is adequately evidenced by the reports and articles published in international journals from well-known publishers.

Science is equally important for everyone. However, its progress strongly depends on substantial investments from all sectors. While the government should be leading, the role of industries and corporate sectors also, is extremely crucial for growth of science and technology. Moreover, it is also a fact that the investments made in education, especially in the higher-level science education, are critical for development of a country. It has often been concluded by economists and social scientists and is generally accepted too. I would like to cite an example from a UNESCO conference held in Dakar in October 2016. UNESCO has repeatedly expressed its commitment to Science, through the promotion of Science Education, and advocacy for Science, Technology, Engineering and the Mathematics (STEM) Education, to make best use of the talents our societies can offer. It was observed in the Dakar conference that investment in Science and Technology is decisive for sustainable development and for economic

growth. Science - as the Director of UNESCO, Dakar reminded - is a tool able to provide us with solutions to the challenges we face, and with its power it can unite people, contributing to peace.

Obviously, scientific knowledge can enable our younger generation with skills and expertise required to tackle very basic problems related not just to food, health, water and sanitation, but also to environment and energy. Interestingly, the two conferences, NULISTICE and RERIS, attempted to cover all these pertinent issues as their themes. Moreover, an exclusive theme focussing on Innovation and Entrepreneurship was like making sense out of all the efforts, because at the end of the day what really matters is that fraction of research output, which gets converted into viable products, solutions to existing problems, and to businesses.

It has been underlined that science, technology and innovation can be "the game changer" for the future development efforts. Scientific knowledge can help enhance the lifestyle of common people and elevate their standard of living. It can contribute to alleviating poverty, creating jobs, reducing inequalities, and enhancing health and general well-being. These features are known to translate directly into better health and improved life expectancy.

In the light of all these points therefore, hosting scientific meetings such as NULISTICE and RERIS in Lesotho was very much warranted and indeed relevant. It should have certainly given the visiting scientists an opportunity to understand the issues as they are in context of a small developing nation. At the same time, researchers who are working within Lesotho must have established some partnerships and collaborations, besides having a glimpse of what the rest of the world is doing in their respective fields.

I can only be proud and grateful for the interest shown by you in these events. Hosting close to 200 participants representing more than thirty different countries from across the globe is not bad at all for a first-timer that we are. But our work does not end here. We should continue the dialogue among all of us so that we can learn from each other. What we all need is to continue working together as we face various challenges. I have been informed that the proceedings of NULISTICE will be published online through the conference website and that of RERIS as a special issue of Proceedings in Energy journal by Springer.

In particular, I would like to take this opportunity to thank all of you here for making NULISTICE and RERIS a success through your valuable contributions and active participation. I would like to thank all keynote speakers, as well as all the moderators, panellists, presenters and attendees.

Finally, I would also like to appreciate the hard work done by various committees that worked so hard with the NUL management to make all of this a great success.

For all of you visiting us from other countries, I hope it had been a memorable trip to the Mountain Kingdom of Lesotho. I wish those who will be flying back in a couple of days, a safe and comfortable journey back home. We will be looking forward to welcome you again in the future.

With these few words, I declare the First National University of Lesotho International Science, Technology & Innovation Conference & Expo, NULISTICE-2018, and Africa-EU Renewable Energy Research & Innovation Symposium, RERIS-2018 officially closed.

Thank you very much.

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National University of Lesotho International Science, Technology & Innovation Conference & Expo
January 23 – 25, 2018
Maseru, Lesotho
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NULISTICE Keynote Lecture

Research, Innovation and Entrepreneurship: How are these Intertwined with Values and Ethics?

Suresh Garg

Vice-Chancellor, Usha Martin University, Ranchi 835221, India.

E-mail: info@ushamartinuniversity.com, vc.ushamartin@gmail.com

Abstract: The present day 'civilized' society is more materialistic but less happy; more knowledgeable but less wise. We are witnessing all-round erosion in values due to growing greed and consumerism. As a result, mutually conflicting behaviour and self-destroying individualism have put human soul to distress. This *crisis of human spirit* has adversely affected various human endeavors, including tertiary education, research and capacity to innovate. The world is now in dire need of creative and visionary entrepreneurs endowed with social values of life, virtues of humanism and respect for composite culture. It is generally accepted that research, innovation, and entrepreneurship reinforce mutually and whither in isolation. Moreover, these blossom in the fragrance of moral, social and ethical values.

Keywords: Research, Innovation, Entrepreneurship, Values and Ethics.

1. Introduction

Hon'ble Vice Chancellor of the National University of Lesotho, Professor Nqosa Mahao, Chairperson of the Conference Organizing Committee, PVC Prof H. M. Lephoto, Prof. Himanshu Narayan, Honorable dignitaries on and off the dais, distinguished researchers, fellow teachers, Invited Guests, Ladies and Gentlemen,

It is great honour, privilege and pleasure for me to be invited to deliver this keynote address in National University of Lesotho International Science, Technology and Innovation Conference and Expo (NULISTICE 2018). I am grateful to the organizing committee for sparing their kind thoughts for me and facilitating my visit to the kingdom in the sky, though I am aware that they must have had many other options for inviting hard core researchers and technologists.

Friends, I am convinced that sub-themes of this conference are extremely relevant in present day reality. It is well accepted that developments in Science and Technology (S&T) have improved human conditions—physical and biological—as never before. We do not have to reach back very far in history to know that life expectancy in some developing societies was not beyond 30 years. But due to medical advances in the 20th century, the arrow of hope began to point upward even in parts of the world where life clinged precariously to bones. The emergence of biotechnology and innovative researches in agro-sciences and genetic engineering kindled hopes for alleviation of human hunger. Better farming practices have made it possible to feed more than seven billion souls. It is no exaggeration to say that scientific research has given us the quality of life of our prescription.

We must realize that there is complex interplay between S&T, socio-economic development and sustainability. For instance, ever increasing quest for comfort and over exploitation of natural resources are affecting environment, and we can ignore environmental issues at our own peril. Climate change has now acquired global dimensions, and collective efforts through initiatives such as Paris Convention and UN Climate Change Conference in Doha are needed to counter its ill influences. Time has come to shun the politics of development. Similarly, the developed nations have to be less concerned about local factors as otherwise these could lead to increase in frequency and ferocity of natural disasters such as failing weather patterns, melting of glaciers and hole in the sky.

It is a well known now that pollutants in the environment lead to depletion of ozone layer with consequent increase in UV rays. This is not only causing huge increase in the number of skin cancer cases the world over but also be fatal for agriculture. (In India, this trend is particularly visible in villages situated on hill tops.) Similarly, rising temperatures are

inducing melting of Arctic as well as Antarctic snow leading to increase in sea levels. We are told that geographical boundaries of many countries would modify by the end of 21st century as several coastal cities would submerge in water across the globe. In the South Pacific, many island nations are confronting this reality even now. Melting glaciers cause floods, which take away fertile layer of the ground affecting agricultural yields. We have to pool human wisdom to seek answers to questions such as: How can we escape ill effects of climate change caused by environmental degradation? Can futuristic researches in material science, nano-technology and information sciences provide appropriate tools? As an optimist, I am of the firm belief that it is within the realm of possibilities; we can plan to bring helium enriched lunar soil to generate energy in a fusion reactor and turn waste into a resource (generate energy out of waste and convert smog into diamonds) An international conference like this is the ultimate forum for exercising brains.

Ladies and Gentlemen, we are living in an era in which we have same faith in science as our ancestors had in religion. In knowledge era dominated by forces of S&T, fundamental scientific researchers will continue to challenge human intellect. Being a student of physics, it is easier for me to cite some examples from physics. Two most vibrant fields of research in physics as of now are at two extreme ends of the spectrum separated by a gap of the order of 10 raise to the power 23—from nano to cosmological dimensions. The best minds are engaged in devising nano devices, studying Higgs Bosons and detecting gravitational waves. As you would know, discovery of Higgs Boson at CERN's Large Hadron Collider (on 4th July 2012) was facilitated by a team of scientists from 26 countries. The financial resources to the tune of eight billion US dollars were pooled by the countries participating in the research project. Similarly, in detection of the four gravitational waves since 2015, scientists from the US and India have pooled intellectual as well as infrastructural resources. This could become possible due to confidence in mutual capabilities and respect for intellect, integrity and honesty of all concerned. The axiom that **Pygmies do not build pyramids** has come true for present day advanced scientific research.

Friends, the title of my talk has three key words: **Research, Innovations, and Entrepreneurship**. I would strive to present how these are intertwined with values and ethics in the knowledge era.

It is said that nature likes simplicity and the most profound things are the simplest. This is also true for affirmative changes achieved through research led innovation and entrepreneurship. In social context, this triumvirate is akin to the combine of monarchy, democracy and pluralism. Just as every morning, daybreak gives us new hopes when we move from darkness to light and changing seasons bring freshness to life, this triumvirate inspires us to strive for seeking microscopic solutions at societal level for the good of our people.

We know that to provide access to quality higher education, encourage research and promote innovations for development driven changes, it is necessary to create competent and competitive value based **social entrepreneurs** who can serve the society with sense of service. For this, higher education has to be democratized to empower suppressed voices and include latent talent pool. However, it ought to be rooted in national values and cultural ethos. Only then education would transform our society from stagnation and poverty to dynamism and prosperity, from marginalization and deprivation to empowerment and recognition, from ignorance and delusion to enlightenment and liberation and from conflict and intolerance to peaceful co-existence and inclusive growth. For this, existing institutions have to be strengthened and new innovative ones created with capacity to strive for **excellence** in research and values. It essentially implies that what is available is to be upgraded to global benchmarks so that our graduates develop abilities to innovate at par with their peers elsewhere. The developing countries have to put particular emphasis on **quality** and entrepreneurship, which emerge as exceptionally good job creators rather than mere job seekers.

2. Research

Research is one of the finest outcomes of human intellect and is fundamental to the intellectual morale of every society. While engaged in a creative and intellectual work, we address questions that actively and continually challenge the discipline's frontiers. We all know that research supports rational debate, unbiased examination of facts and ability to question existing practices and theories in the light of new evidences, i.e. research develops discipline of dissent. And, research is intrinsically coupled with values such as honesty, creativity, innovation, objectivity, truthfulness, foresight, openness and tolerance.

The outcomes of research satiate human curiosity to explore newer horizons and go beyond the known. This has been facilitated by continuous pooling of knowledge ever since a South African cave provided the earliest evidence of fire control by our ancestors some one million years ago. (It is another matter that pace of S&T research accelerated in the last 300 years and overtook social developments of 3000 years.) This undoubtedly proved the most significant milestone in the cultural evolution of human race; it not only provided protection against the elements but also facilitated human geographical dispersion.

It is no exaggeration to say that research is absolutely essential for economic empowerment of any society. Unfortunately, talented students in the developing world have lure for lucre and research is no longer their first priority. To some extent, shifting priorities of federal governments have also contributed to this malaise. To give you an idea of numbers, the differential in the investments in scientific and technological R&D vis-a-vis advanced economies is 1: 250. As a result, 80% – 90% of new knowledge is being created by the rich countries and more than 90% Intellectual Property Rights are owned by them. The point I wish to make is: Third world researchers have not won international recognition for propounding landmark breakthroughs. Such disparities are creating knowledge divide, which does not augur well for us. In this background, I am of the considered view that genuine researchers should be provided liberal support. Moreover, we must guard against the newer reality of crass commercialization of higher education to the extent of denial to the poor and marginalized.

3. Innovation

Innovation is successful implementation of creative ideas within an organization or system. From this perspective, creativity of an individual is the starting point for innovation. In general, innovation has been understood variously. According to management Guru Peter Drucker, **innovation is a change that creates a new dimension of performance**. Jose Campos, Founder *Rapid innovation*, considers **innovation as the ability to deliver new value to a customer**. Steven Paul Jobs argued that **innovation differentiated a leader from the laggard**. But conventional understanding about innovation is **commercialization of invention, which refers to new concepts or products that derive from individual's ideas or from scientific research**.

An innovation must be replicable, economic and responsive to a specific need. Innovation involves deliberate application of information, imagination and initiative in deriving greater or different value from resources, and encompasses all processes by which new ideas are generated and converted into useful products. In short, **an action can be identified as innovation if it is new and useful to the system, increases efficiency, is cost-effective, and compatible with or adaptable by other similar systems**.

In business, innovation reduces the gap between expectations of users and performance of products. In social context, innovation refers to devising new collaborative methods such as alliances and partnerships, and in creating buyers' purchasing power. **In education, innovation lies in continuous march towards excellence by involving all stakeholders and devising improvement in various processes to improve learners' progression curve through learner-friendly teaching-learning support from the time a learner registers in a programme till she is certified successful.**

Since teaching-learning is characterized by *transformation and change*, some innovative practices include:

- Creative application of technologies to seamlessly connect with learners to develop domain knowledge and employable skills/competencies;
- Apply innovative pedagogies and media strategies to address learning challenges and situations;
- Make imaginative interventions through best practices;
- Practice ethos of sharing and collaboration to economize on energy, funds and time;
- Develop dynamic assessment tools to continuously measure learner performance in terms of achievement of learning outcomes; and
- Manage knowledge available in public domain for conservation of cultural heritage, values and such other assets.

So in the context of higher education, **innovation implies research based continuous improvement in processes of knowledge creation and its delivery, learner engagement and assessment with due consideration of cultural heritage and societal values**.

We know that now-a-days knowledge is being created very rapidly and in some front-ended fields, the knowledge doubling time is 2-3 years. To keep pace with such developments, it is important to raise commensurate structures. Finland took lead when it merged its top business school, design school and technology school to create value for its people through a multi-disciplinary "University of Innovation". In India also, the Federal Government has created a blueprint to create innovation universities to promote quality of education. Though this idea is being opposed by the purists amongst the intelligentsia, I am of the considered opinion that it should be given serious consideration.

It is interesting to mention here that throughout history, most inventions were inspired by the natural world. But the only100% *homo sapient* innovation is that of wheel. Evidences indicate that it first made appearance around 3500 BC in Mesopotamia to serve as potter's wheel. But its usage evolved with time; it has been used for irrigation, milling, transportation, games and entertainment. In his efforts to create perpetual motion device, Pascal invented "Roulette", the small wheel and the big wheel "London Eye" is an iconic 'entertainment' landmark on the banks of Thames. In the twentieth century, revolutionary changes in

transportation incubated internationalization have led to multi-cultural societies and global citizens.

It would not be out of place to mention here that innovation should not be confused with creativity, which is confluence of knowledge, out of box thinking and hard work. However, application of a creative idea and its realization in action is innovation. That is, **innovation is a new way of doing something which leads to changes in thinking, products, processes or an organization**.

4. Entrepreneurship

The concept of entrepreneurship is believed to have been coined around 1700's and since then, it has been defined in many ways. According to Schumpeter, entrepreneurship is the carrying out of combinations of a new product, a new method of production, opening a new market and carrying out a new organisation of industry. Peter Drucker considered entrepreneurship as a practice, which embodies risk taking, innovation and venturing into new business activities for profit. The National Knowledge Commission appointed by the Indian Prime Minister in 2006 defined entrepreneurship as professional application of knowledge, skills and competencies and/or monetizing a new idea by an individual or a group of individuals by launching a new enterprise de novo. That is, to pursue growth while generating wealth, employment and social good.

An entrepreneur has capability to identify unnoticed opportunities in ambiguous situations, harness resources to convert the opportunity into a venture and possesses skill to make creative pathways. That is to say, an innovative entrepreneur has vision and dreams, achievement motivation, clarity of thought and strength to survive. Above all, she has ability to take risk and willingness to invest her intellect, effort and money. She strongly believes in the axiom one designs and many built. Narayan Murty, Steven Jobs, Bill Gates, Travis Kalanick and Mark Zuckerberg are some familiar entrepreneurs of the past fifty years.

Entrepreneurship involves disruptive innovation or creative destruction wherein a new revolutionary idea leads to downfall of existing practices, norms, industries or people. Introduction of Uber and Oyo provided cost-effective and reliable alternatives to commute and boarding. In fact, these are very good examples of disruptive innovation. Similarly, introduction of personal computers and mobile phones, which led to downfall of mainframe computer companies and landline phone companies, respectively, are also great examples of creative destruction.

In education, visionary entrepreneurs increased access to quality education through public and private initiatives by establishing institutions such as Cambridge, Harvard, Stanford, Wharton, Yale, Cal Tech, Oxford, NUS, Cambridge, etc. We all know the premium attached with these institutions. Similarly, William Rainley Harper, Sir Issac Pitman, John Wilkinson Taylor, George Siemens, Otto Peters, Asa Briggs, Walter Perry have been pioneers of open and distance learning were first rate educational entrepreneurs who continued to march ahead against all criticism and ultimately succeeded in providing a reliable complementary mode to learn in a very rich environment created using information and communication technologies. More recent disruptive innovations in higher education are the MOOCs and mainstreaming of Open Education Resources (OERs).

Despite such affirmative developments in knowledge creation and dissemination, the society is witnessing all-round erosion of values due to growing greed and quest for comfort. There is dire need of creative entrepreneurs, who in their earlier incarnation worked as social reformers like Swami Vivekananda and Martin Luther King Jr, with a vision encompassing value-orientation of society and empowering the youth to inculcate values of life and virtues of humanism for harmonious living in composite culture.

5. Ethics and Values

Ethics is a concern for others—all living beings in nature. Ethics covers rules of righteous conduct and behaviour. That is to say, an individual should be ethical in thought, word, action, transaction and relationships towards fellow beings, in business/profession and to other life-forms. Ethics applied to family means that partners are mutually respecting, accommodating and sympathetic. A religion is ethical in its relationship with other religions through observance of values such as tolerance, non-interference and peaceful co-existence.

Ethics are powerful determinants of moral, religious, spiritual, social and professional conduct. These provide sound foundations to a civil society and call for adherence to judgements grounded in values of life. At the social plane, aspects such as equity, human dignity, gender equality, social justice, liberty and freedom, privacy and confidentiality constitute ethics. In medical science, professional ethics became recognized in the form of Hippocratic Oath as early as 400 BC. However, in fields such as management and business, science and technology, professional ethics are of recent origin. The bio-agro-nano-info driven debates have serious implications for ethical values in scientific research. It is therefore, both necessary and desirable for every society and institution to create awareness about and guard against unethical practices.

In the context of education, observance of ethics has implications for all stakeholders associated with

delivery of education. Observance of ethical values on the part of an organization demands that it provides value for money and time. It must therefore,

- Observe core values such as transparency, accountability and learner-sensitivity;
- Act democratically where decisions are taken through wider consultations and everyone associated with it nurtures ownership feeling;
- Cherish academic freedom and continuously work towards excellence;
- Fulfill its core function of developing learners as responsible citizens with required values; and
- Practice time-tested strategies for financial management and accountability to all its stakeholders.

Values are attributes which we as individuals and collectively as society consider important. While truth, honesty, integrity, love, compassion, and peace are universal values, beauty and goodness are supreme intrinsic values of life. Pursuit of non-violence for achievement of peace is an instrumental value. Perfection and thoroughness in task/job/profession are technical values. Pursuit of peace may imply pursuit of several inter-related values like self-discipline, tolerance, unity, harmony, friendship, faithfulness, sincerity, etc.

Gratitude, indebtedness and Ahimsa are vital cultural values. We feel grateful to our parents for our up-bringing and character building; obliged to our teachers for providing knowledge and skills; and to Mother Nature for various gifts, which make life comfortable and enjoyable. Our educational programmes and activities will do well to espouse and foster these values to create responsible, discerning and law abiding citizens, who can control themselves in trying moments.

In present times, wisdom and knowledge are not in equilibrium and there is growing dehumanization of soul. The present day civil society is materialistically rich but less happy; more knowledgeable but less wise and low on humanity. In fact, mutually conflicting behaviour and self-destroying individualism have put human soul to distress. For this crisis of human spirit, we cannot be proud of the moral standards of digital natives. Some people tend to view these developments as a sign of evolution of society but I am of the considered view that such undesirable trends are a result of erosion of values. And to find a way out of the chaos, we need the wisdom of the likes of Mahatma and Madiba and inculcate social values, strive for morality in action and shed greed, hatred, conflict and violence.

6. Research, Innovation and Values

As such there are no facile formulae for innovative research but philosophy of Aanekantvad, which is central to Jainism, highlights respect for the views of 'many'. Values such as clarity of thought, openness, objectivity, and determination to achieve the goal, foresightedness, conviction and truthfulness to purpose are integral to research and pave way for pursuing unconventional paths and for innovations. Moreover, the value system of a researcher is very vital for sustenance of innovations.

7. Innovation, Entrepreneurship and Values

We now know that the goal of innovation is to usher positive change like cutting cost, improving quality and maximize productivity. For fostering innovation, an entrepreneur implements his ideas initially at microscopic scale. And to be successful, he has to be ethical with his business partners and honest in transactions with individuals as well as the state. It is another matter that entrepreneurship in some emerging economies is envied the world over for their persistence rather than their ingenuity.

8. Conclusions

I would like to say towards the end of my talk that innovation and entrepreneurship have two way relationships and it would only bloom in the nurturing culture of ethics and values. The innovator germinates and an entrepreneur implements the idea. The entrepreneurial culture drives creation of wealth from knowledge, creates jobs and paves way for further innovation.

I conclude by observing that if we have to leave our imprint on the 'sand of time', we have to continuously innovate and overcome tendency for maximization of material wealth. There is now a need to know the mind, to shape the mind and to liberate the mind from greed and self-centeredness more than ever before. We have to integrate knowledge with wisdom while innovating with entrepreneurial spirit for the welfare of society.

The author Professor Suresh Garg is currently the Vice-Chancellor of Usha Martin University, Ranchi, India. Prior to taking this assignment, he had served as Pro-Vice-Chancellor and Professor of Physics at Indira Gandhi National Open University (IGNOU), New Delhi. He was at NUL for two years during 2008 – 2010 as Founding Director, Centre for Teaching and Learning (CTL) on secondment of the Commonwealth Secretariat, London. He can be contacted at: vc.ushamartin@gmail.com

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Production and Utilization of Conserved Barley and Oat Grass as Fodder for Merino Sheep

P.E. Mosebi*, M.P. Ntakatsane, P.A. Matebesi-Ranthimo, R. Makata

Department of Animal Science, Faculty of Agriculture, National University of Lesotho, Roma 180 Lesotho.

***Corresponding author:** Phone: (+266) 5670 0610; E-mail: pe.mosebi@nul.ls

Abstract: Barley (*Hordeumvulgare*) and Oat (*Avenasativa*) are cultivated cereal foragesadapted to dry season conditions. Conserved cereal forages provide nutritious fodder for sheep in winter and spring months. The objective of this study was to evaluate nutritional composition of conserved barley and oat and assess performance of merino sheep fed conserved fodder. The experiment was conducted from February to December 2017, in a complete randomized block design with three replications. Treatments consisted of two conserved forages barley and oats.Six Merino sheep ewes(Body weight = 25±3.25kg) were given 300g in separate feeders daily. Conserved forage were analysed for nutritional composition represented by dry matter, crude protein, neutral detergent fibre (NDF) and acid detergent fibre (ADF). Body weight gain was measured for merino sheep performance.Dry matter and crude protein of conserved oat forage was significantly higher than that of conserved barley forage. Neutral detergent fiber and acid detergent fiber were lower in conserved oat compared to conserved barley. The body weight gain values obtained by sheep fed oats were higher than those fed barley. The results of this study indicate that conserved oat forage had an impact on nutritional composition and body weight gain of merino sheep.

Keywords: Barley, Oats, Merino sheep, Nutritional composition, Body weight gain.

1. Introduction

Merino sheep is of great importance to Lesotho prosperity for both economic and social reasons. Sheep are kept primarily for production of wool and mutton. Most of country's output of mutton or lamb is consumed locally. Wool sheep produces about 3500 tons of raw wool annually for export and granting employment opportunities to hundreds of inhabitants [1].Sheep are also used for such social obligations as payment of bride price, payment to traditional healers, burial and wedding ceremonies. Sheep have played a significant part in the education of the rural people as live sheep and/or wool is sold to raise money for school fees. Use of dung as manure is apparently common in the regions where there is relatively more crop farming [2]. The major constraints to increasing merino sheep production in Lesotho include scarcity & fluctuating of yield and quality of year round forage supply. Most Lesotho sheep producers do not have productive pastures and currently graze their animals on poor and undeveloped grasslands. Inadequate feeding is a major limiting factor to merino sheep production especially during winter season, when grazing areas have limited quantities of forage. Moreover, winter forage is of poor nutritional value due to the unfavourable weather conditions. Introduction of planted forages especially temperate (cool season/C_3) grasses in dry season is very beneficial to increase productivity of forage supply. Barley (*Hordeumvulgare l*) and Oats (*Avenasativa*) are temperate (cool season/C_3) grasses and generally categorized as grasses that thrive in cooler climates or during cooler seasons [3]. Temperate grasses are an excellent choice for winter pastures or fodder fields, a cover crop, and adapted to a wide range of soil and weather conditions. Temperate grasses would be productive in response to the situation of weather conditions in Lesotho because of the cooler temperatures during autumn, winter or spring season. The objective of this study was to evaluate nutritional composition of conserved barley and oat fodder, and impact of conserved fodder on body weight gain of merino sheep.

2. Material and Methods

Study area:

The study was conducted at the National University of Lesotho, Experimental Farm in Roma, Lesotho. The area is located at altitude of 1500m above sea level with an average annual rainfall and temperature of

750mm and 22^{0}C, respectively. The predominant soil type of this region includes yellow brown loamy soil with medium to coarse textured.

Production of fodder:

Soil was tested in February 2017 to determine the lime and fertilizer requirements to ensure good barley and oats establishment. A seedbed was prepared from existing improved grassland of 1 ha area. Two temperate grassesbarley (*Hordeumvulgare l*) and oats (*Avenasativa*) were planted on February 2017. Fodder was harvested at booting stage for hay making. Fodder materials were collected and store in form of hay rolls. The harvested hay was stored for a period of 30 days before merino sheep utilization.

Experimental design:

The experiment was conducted in a complete randomized block design with three replications. Treatments consisted of two conserved forages barley and oats. Two merino sheep group, with three merino sheep per group randomly allocated to two treatments barley and oats fodder housed in separate kraals.

Animals:

Six merino sheep ewes with initial average live weight of 25±3.25kg were used. Merino sheep randomly fed barley and oats fodderwere housed in separate kraals for a period of 60 days. The conserved fodders were given at the rate of 300g twice daily in the morning & afternoon. Fresh water was provided on daily basis and routine medication was also adhered to strictly.

Nutritional composition:

Conserved forage were analysed for nutritional composition represented byDry matter (DM), Crude protein (CP),Neutral detergent fibre (NDF) and Acid detergent fibre (ADF). Samples were randomly taken from selected conserved barley and oats. Conserved fodder samples were submitted tothe Department of Animal Science Laboratory for analysis. The samples were oven dried to constant temperature of 105^{0}C for 24 hours to determine dry matter content. Crude protein (CP) based on DM was calculated by multiplying the Nitrogen (N) content by 6.25 determined using Kjeldahl method [4]. NDF based on DM was measured by boiling a forage sample using neutral detergent under neutral pH conditions. ADF was determined using acid detergent under low pH condition [5].

Body weight gain:

Body weight gain of each merino sheep from all the treatments was measured on weekly basis using an electronic scale.

Statistical analysis:

Plant and animal data were subjected to ANOVA using Statistical Analysis Systems Software Version 9.1 [6]. Differences were considered significant at P≤0.05 and means were separated using a Fisher's protected Least Significant Difference (LSD) test. Tukey's multiple range test was conducted for mean comparison.

3. Results and Discussion

Nutritional composition- Dry matter yield:

Dry matter yield of conserved oat and barley fodder is presented in Figure 1. There was a significant difference among fodder dry matter yield for the conserved oat and barley. Dry matter yield was significantly higher in conserved oats fodder than conserved barley fodder. This difference is likely to be associated with spatial use of resources, roots for water and nutrients, leaves for carbon dioxide and light, which made oats able to efficiently utilize and convertthose natural resources into growth attributes. Previous studies reported a similar response of more dry matter yield from oats than barley [7,8].

Chemical composition:

Chemical composition of conserved barley and oats fodder is presented in Figure 2. Fodder chemical composition data indicated that there was significant difference among treatments of conserved oats and barley. Maximum crude protein (CP) content was obtained from conserved oats and the lowest from conserved barley fodder. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) was significantly higher in conserved barley than in conserved oats. The results showed that conserved oats produced higher crude protein content than conserved barley fodder, which could be the result of efficient utilization of soil nutrients and moisture. Conserved oats fodder has low

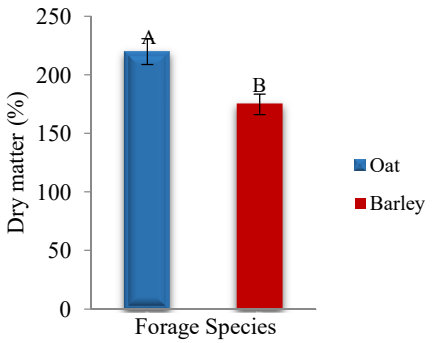

Figure 1. Dry matter of oat and barley fodder.

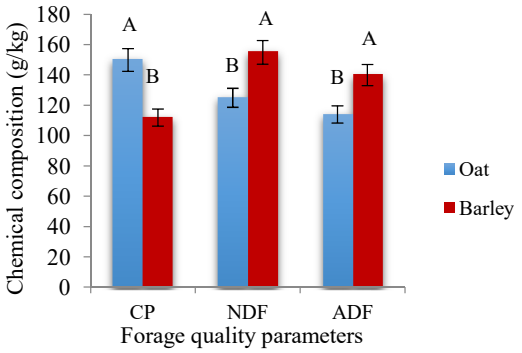

Figure 2. Chemical composition of oat and barley fodder.

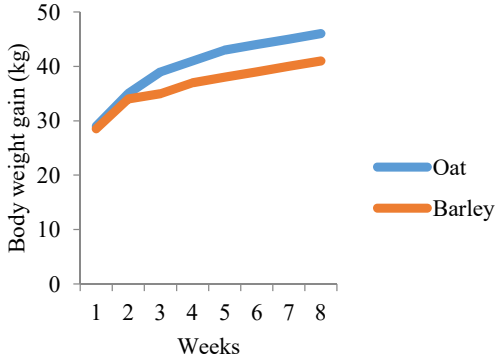

Figure 3. Body weight gain of merino sheep fed oat and barley fodder.

NDF and ADF values whereas conserved barley fodder has high value. High NDF and ADF values could be partly due to insufficient use of natural resources such as atmospheric gases, sunlight and soil nutrients. These results are in line with the findings of other studies, which reported that optimum use of nitrogen, carbon dioxide, solar energy, moisture, soil micronutrients and macronutrients by plant increases crude protein and lower neutral detergent fibre and acid detergent fibre [9,10].

Body weight gain:

Body weight gain of merino sheep fed conserved oat and barley fodder is given in Figure 3. Body weight gain data revealed that there was significant difference among treatments for period of eight weeks. The body weight gain values obtained by merino sheep fed conserved oats were higher than those fed conserved barley. This higher body weight gain values of merino sheep fed conserved oats fodder might be due to high levels ofdry matter yield and crude protein available in oats fodder. It has been reported that level of protein and dry matter availability in fodder dietsefficiently interacted to give the highest total weight gainfor lactating ewes [11]. Other study work reported that there was a decline in daily weight gain as the high levels of neutral detergent fibre and acid detergent fibre were noted in the fodder treatment diets [12].

4. Conclusions

Results obtained from this study showed that conserved oat fodder had better dry matter yield and chemical compositionthan conserved barley fodder. Conserved oat fodder promoted higher body weight gain in merino sheep than conserved barley fodder. Considerable efforts have to be made to improve feeding regimes for merino sheep through established forage crops.

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Evaluation of Microalgae Sludge as Biofertilizer for Growth of Maize Under Greenhouse Trials

'Mammatli Kompi[1], S.B. Mekbib[1,*] M.J. George[2]

[1] *Department of Biology and Biotechnology.*
[2] *Department of Chemistry and Chemical Technology,*
Faculty of Science and Technology, National University of Lesotho, P.O. Roma 180, Maseru, Lesotho.

***Corresponding author:** Phone: (+266) 63242329; E-mail: sbmekbib7@gmail.com

Abstract: The importance of microalgae is justified by its nutrition content especially the presence of carbohydrates, lipids and proteins which make it useful in a wide array of applications including biogas production. In the present study microalgae sludge was obtained as a by-product of biogas production by two formulations, one digested with cellulose degrading microorganisms (CD) and the other without CD and their potency when used as a bio-fertilizer compared with the other organic manures, namely, cattle manure and chicken manure as well as the mineral fertilizer NPK 2:6:1 (36). To this end, maize - a staple food in Lesotho, was used as a model. Different applications on acidic and neutral soils were evaluated given the widespread acidic soils in Lesotho. Microalgae sludge + CD increased maize growth in both acidic and neutral soil by more than 100% and about 15% respectively compared to the negative control. Microalgae sludge + CD also effected the maize biomass more than the negative control in both soils, suggesting the effectiveness of microalgae sludge + CD in improving growth of maize. Deeper research into microalgae sludge, especially the application rates and application methods on different crops still has to be studied and put into use.

Keywords: Microalgae sludge, Cellulose degrading microorganisms.

1. Introduction

In agriculture the major management goal is to increase and maintain soil quality with high biological activity and excellent crop yield. Farming practices which involve heavy application of chemical fertilizers may cause depletion of certain nutrients in the soil and certain other nutrients would generally accumulate in excess, resulting from nutrient imbalances which affect the soil productivity. In addition, excessive use of chemical fertilizers increase nitrate, nitrite, ammonium, phosphate and other reactive chemical species in the ground water and surface water bodies, which is a serious environmental and health hazard [1], adding to its high values costs. Heavy applications of chemical fertilizers also reduce soil fertility by changing the soil pH balance [2].
Their preference in agriculture over chemical fertilizers offers an economic and ecological benefit by improving soil health and fertility. When these bio-fertilizes are added to the soil, the contained microbes colonise the rhizosphere or interior of the plant, enhancing the plant's ability to absorb nutrients necessary for root development, promoting the uptake of nitrogen and water as well as production of hormones that stimulate the growth of the plant and its resistance to e.g. diseases, drought and soil salinity [3] and resistance to moisture stress [4].Several investigations have been carried out and showed that application of bio-fertilizers increase crop yield by 20-30%, replace chemical nitrogen and phosphorus by 25% in addition to stimulating growth [4]. It has been reported that microalgae sludge has more nitrogen content than most bio-fertilizers, it contains macronutrients, carbohydrates, proteins and vitamins implemented for improving growth and yield of crops [5]. Nitrogen in plant growth is required for synthesis of enzymes, proteins, chlorophyll, DNA and RNA. Bio-fertilizers add nutrients through natural processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through synthesis of growth promoting substances [4]. A small dose application of a bio-fertilizer is sufficient to produce desirable results because each gram of a bio-fertilizer contains about 10 million viable cells of a specific strain [6].

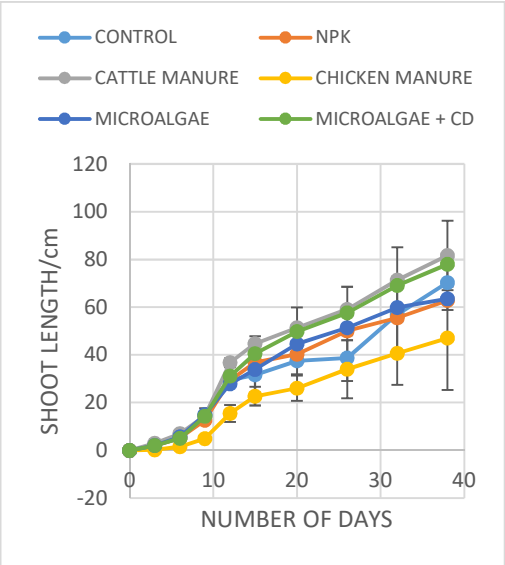

Figure 1. Effects of different fertilizers on maize growth in natural soil.

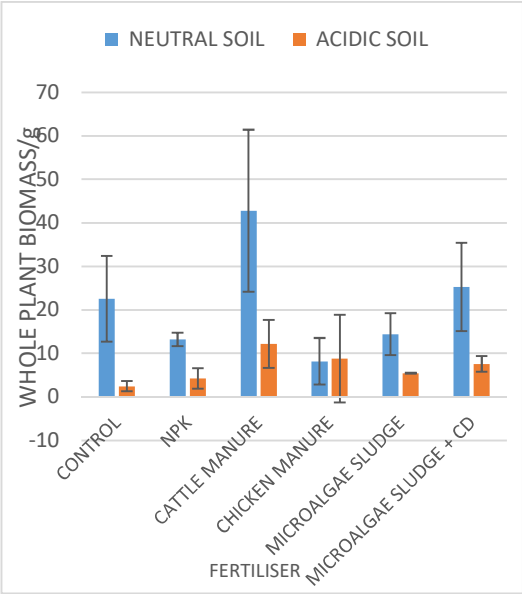

Figure 2. Effects of different fertilizers on the wet biomass of uprooted maize plants.

Use of microalgae sludge as bio-fertilizer provides all required organic and inorganic nutrients for the plant to grow. Besides, it is free of pathogenic microorganisms and contains more than 70% of organic compounds as it has been reported from laboratory experiments [7].

2. Material and Methods

Sampling:

Sewage water microalgae was collected in 10 5L plastic bottles from the sewage water pond at the National University of Lesotho (NUL). Half of the bottles containing microalgae were each inoculated with 1ml of cellulose degrading microorganisms and then incubated for 10 days to allow biogas production. Acidic and neutral soil were collected from Ha-Mafefooane and NUL respectively. The soil was sterelised at 121°C and 15lb for 30minutes. About 2kg of the soil was then added into 18 4L plastic pots separately. Subsequently, fresh chicken manure and cattle manure were collected in plastic bags from NUL farm. The manures were ground separately for particle uniformity. The manures were then mix evenly with the soil, each in triplicates for the different soil pH, at a rate of 133g/2kg of soil together with commercial NPK 6:2:1 (36) fertilizer separately. Three pots for each soil type were not treated with fertilizer to serve as negative control.

Greenhouse experimentation:

The pots containing treated soil were kept in a greenhouse for 24hours. Pure breed viable maize seeds were sown in all the pots and allowed to grow. The pots were watered according to the water requirements of the sol. Weeding was done whenever necessary to eliminate competition between the maize and other plants. The maize shoot growth was measured every 3 days for 3 weeks. At the end of the experiment, the shoot and roots biomass was determined..

3. Results and Discussion

Maize plant development:

The five fertilizers applied separately in neutral and acidic soil showed a significant different in effecting the growth of maize. But generally all the fertilizers showed a better performance in neutral soil as compared to acidic soil. Cattle manure exhibited the highest growth development of maize shoot followed by microalgae sludge digested with cellulose degrading microorganism (CD) and thirdly, microalgae sludge without treatment. Compared to all other fertilizers, chicken showed the slowest growth development of the maize shoot with very pale looking shoots. Chicken manure increased the pH values in all the soils. The results in Figure 1 showed that chicken manure exhibited lowest growth as compared to other fertilizer treatments. This could be unexpected since chicken manure contains potentially useful amounts of N and large proportions of P and K as compared to cattle manure. This could be attributed to the increase in pH; this is an unbearably high pH for maize to tolerate. Maize grows optimally at pH 6.0-7.2 [8]. Attributes this increase in pH to presence of calcium in chicken manure. It is the high pH and the water lodging effect which make this nutrients unavailable for

plant uptake, however, large proportions of N can also be lost as ammonia gas, leaving the manure insufficient of N; nutrient responsible for growth of plants since it's essential for cell division.

Maize plant biomass

Soil treated with cattle manure produced the greatest plant biomass followed by microalgae treated with cellulose degraders (Figure 2). These results were more observable in neutral soil more than in acidic soil. This results suggest that the neutral soil was sufficient of the necessary nutrients required for maize growth in addition to the known pH suitable for maize growth (pH 6.94). The correct pH ensures that nutrients are available to crops as well as the good soil structure, which enhances root development.

4. Conclusions

Result of the study revealed that microalgae sludge pre-treated with cellulose degrading microorganisms improve maize growth. The improved performance is also similar to that achieved with cattle manure fertilization. The study further showed that chicken manure and NPK do not give the best growth of maize. It is therefore in the best interest of agricultural production and its improvement to replace chicken manure, NPK and other chemical fertilizer with the use of microalgae sludge digested with cellulose degraders. Application of 150tonnes/ha of microalgae sludge + CD was capable of increasing growth of maize by more than 100% in acidic soil and by about 5% in neutral soil over the negative controls. More research into microalgae sludge, especially the application rates and application methods on different crops is needed.

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Evaluation of animal manure as a feedstock for the production of biogas in comparison with sewage water microalgae

Matlosa T.[1], George M.J.[2], Mekbib S.B[1,*]

[1] *Department of Biology and Biotechnology.*
[2] *Department of Chemistry and Chemical Technology*
National University of Lesotho, Roma 180, Maseru, Lesotho.

[*]**Corresponding author:** Phone: (+266) 6324 2329; E-mail: sbmekbib7@gmail.com

Abstract: The use of fossil fuels as energy sources have impacted the environment and the economy negatively as they are the major sources of carbon emission to the environment. It is therefore important to find cheap and clean sources of energy options to protect the environment. In this study, the use of animal manure: cattle and chicken drops were assessed in comparison with microalgae as sources of feedstock for the production of flammable biogas. Semi quantitative and qualitative data analyses were carried out to evaluate the biogas produced from these feedstock sources. The biogas from chicken manure was not flammable indicating the presence of high concentration of carbon dioxide compared to other feedstock sources. High quality of biogas was produced when microalgae was digested by the cellulose degrading microorganisms. However, the initiation of the decomposition process and production of gas took a little longer time compared to the chicken and cattle manure. Though, the chicken drops shown high volume of CO_2 production, the mix of feed stock with other carbon sources such as microalgae to maintain the C:N balance, would enhance the decomposition process faster to produce a flammable biogas.

Keywords: Biogas, Chicken drops, Methane, Cattle manure, Microbial decomposition, Microalgae.

1. Introduction

Fossil fuels have been used across the globe as the means of energy for many years. In the world 88% of the annual primary consumption accounts for fossil fuels [1]. Fossil fuels are the largest contributor of greenhouse gases to the biosphere and are responsible for 99% of carbon dioxide into the atmosphere [6]. So fossil fuels contribute to the pollution of the environment and increase the greenhouse effect that brings climate change. Natural processes are unable to remove the greenhouse gases from the atmosphere at the rate they are being emitted hence the effects of global warming are severe. Besides, there are frequent rises in fuel prices due to the diminishing reserves of fossil fuels [4].

Waste water microalgae, human and animal excreta can be used as the alternative sources of biofuel through their anaerobic digestion. Anaerobic digestion is a biological process performed by many classes of bacteria and generally consists of four steps namely hydrolysis, acidogenesis, acetogenesis and methanogenesis [7]. Moreover, the final product of this process which is methane can be used as fuel for vehicles or co- generation of electricity and heat thereby leading to reductions in greenhouse gas emissions. Anaerobic digestion of microalgae was extensively analyzed and concluded to represent an essential step in the development of an integrated and cost efficient microalgae-based process of carbon dioxide capturing and methane production [9].

2. Materials and Methods

Sample collection area:

All samples: sewage water microalgae, chicken manure, cow manure and waste water were collected from the farm site at the National University of Lesotho. Samples were collected in 5L water collecting containers and carried to the Microbiology laboratory, department of biology.

Treatment formulation:

Two sets of experimental approaches with or without cellulose degrading microorganisms were designed. A mass of 300g of each of the collected samples were measured and placed in 5L bottles which served as

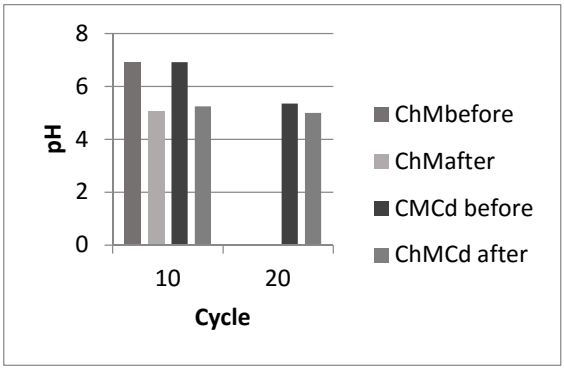

Figure 1. pH of water before and after bubbling with biogas produced from chicken and microalgae feedstocks.

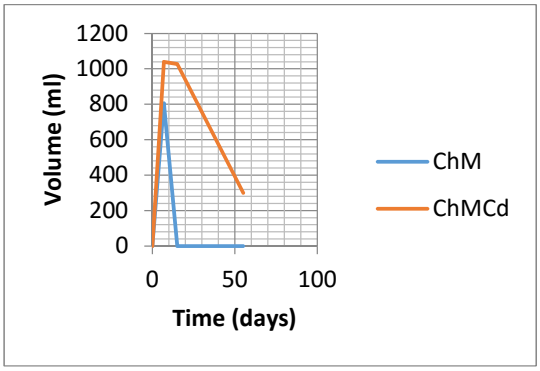

Figure 2. Volume of biogas produced.

anaerobic digesters. Equal volume of waste water from the donga (0.45L) were used to the chicken and cattle manure as a starter, which latter was filled up by adding 3.5L of tap water. Containers with microalgae were filled with microalgae sewage water (4L) The experiment was done in duplicates and repeated once.

Digester assembly and incubation:

A 5L capacity plastic bottles were used as laboratory scale anaerobic digesters and dry infusion bags were fitted on each digester to collect the biogas. The lids of the digesters were tightly fitted and carefully punctured at the center. Needles and tubes were used to connect the digester to the infusion bags. Careful folding of the tubes was taking care of as ensured to prevent any kinks which may impede gas transfer. The anaerobic digester contents were incubated at the greenhouse temperature maintained between 27-30^{o}c and daily inspection of the gas production was done by observing the swelling of the bags.

Determination of gas volume:

Displacement method was used to determine the volume of gas present in the infusion bags.

Determination of pH:

The gas was bubbled through distilled water and the pH measured for the analysis of the presence of acidic gases present. The pH of the distilled water was measured before and after bubbling with distilled water.

Flame test:

Flame test was carried out using a small needle to determine the gases color produced from the end of the needle flame. The gas was then bubbled through aqueous $Ca(OH)_2$ for the determination of the presence

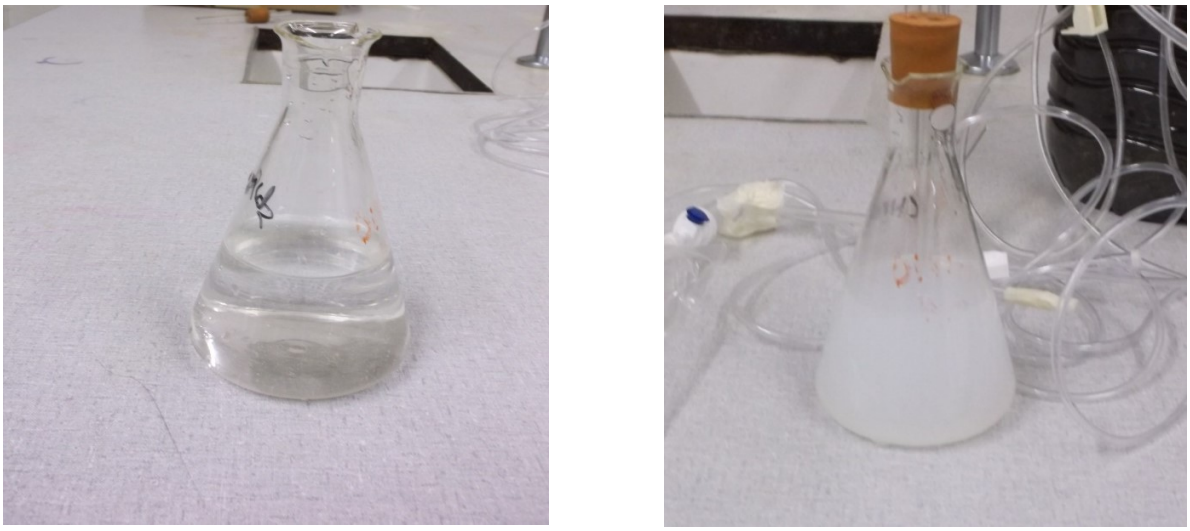

Figure 2. Calcium hydroxide before (left) and after (right) after bubbling with biogas.

of CO_2 in the gas.

3. Results and Discussion

Determination of gas pH:

The pH of water during both the first and second cycles dropped below neutral after bubbling with biogas from the digesters (Figure 1).

In this study, it was observed that the pH of the gas determined from the feedstocks digestion in the simulated lab scale anaerobic digesters was acidic (Figure 1). The acidity could be due to the presence of volatile fatty acids in the reactor. The build-up of volatile fatty acids due to acidogenic bacteria present in the bioreactor results in the decrease of pH [2]. The pH drop could also be due to the action of sulfate-reducing bacteria present in the reactor. Under anaerobic conditions, sulfate reduction microorganisms may have also produced hydrogen sulfide (H_2S) which lowers the pH significantly [8]. Moreover, the presence of carbon dioxide (CO_2) due to the action of acetogenic as well as sulfate reducing bacteria has an effect on the acidity of the content in the system. Carbon dioxide produces carbonic acid in the presence of water ($CO_2 + H_2O \leftrightarrow H_2CO_3$). The presence of H_2S and CO_2 in the gas makes it unsuitable to use since H_2S contributes to sulfur dioxide emissions and can be corrosive when present with moisture. CO_2 on the other hand reduces the heating capacity of the gas.

Determination of gas volume:

Higher gas volumes were collected from digesters inoculated with cellulose degrading microorganisms (ChMCd) than in chicken manure alone (ChM) (Figure 2). Moreover, these digesters further produced gas while those without cellulose degraders could not.

The production of gas in chicken manure started three days after the anaerobic digesters were capped. The manure was fresh from the farm and had high moisture content. According to [3], water is one of the necessary requirements for growth of microorganisms. This says that even before the manure was to be anaerobically digested there was already a large number of microorganisms present in the manure. Moreover, chicken manure is very rich in nitrogen which is one of the macromolecules necessary for bacterial growth [3]. Being exposed to the anaerobic conditions, the already large number of facultative and aerotolerant microorganisms proliferated and as they metabolized they produced sufficient volumes of gas. As illustrated in Figure 3, the highest gas volume was seen in the digesters inoculated with cellulose degrading microorganisms (ChMCd) and such digesters continued to produce gas. The cellulose degrading microorganisms further degraded any cellulose present in the manure through hydrolysis thereby providing substrate for acedogenic microorganisms [10]. This therefore seems to improve the gas production, as the cellulose degrading microorganisms provide the carbon substrate for the acedogenic microorganisms.

Figure 4. Royal blue microalgae biogas flame.

Test for carbon dioxide:

The white precipitate was observed when the gas was bubbled through water (Figure 3).

A white, milky precipitate was observed when the gas was bubbled through calcium hydroxide ($Ca(OH)_2$) solution (Figure 3), which represented by the following reaction:

$$CO_{2(g)} + Ca(OH)_{2(aq)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$$

Carbon dioxide is one of the major compounds found in biogas and its percentage can be as high as 45% depending on the substrate used for anaerobic digestion [5]. In this study, it was investigated that the cattle and chicken manure when used as a feed stock alone, the amount of CO_2 produced was very high and the flame test shows negative result due to the nature of the gas produced, i.e Carbon dioxide is produced in all the stages involved in the anaerobic process except during hydrolysis. So, it is advisable to use a mix biomass feed for the anaerobic digester.

Flame test:

Chicken manure is very rich in nitrogen and during its anaerobic digestion ammonia is generally abundant in high concentrations. Ammonia inhibits the methanogenic bacteria thereby lowering the rate at which methane is produced [2]. In general, gases that are present in higher concentrations are those that do not support burning e.g carbon dioxide and ammonia, and those that are toxic when burned e.g hydrogen sulfide. So, it is advisable to use a mix of biomass

Table 1. Burning characteristics of the gas

digester	characteristic
ChM	No burning
ChMCd	No burning
Ma	Blue flame
Ma +cd	Blue flame

sources to be used as a feedstock for the production of biofuel. Gas from anaerobic digestion of microalgae (Ma) burned with a blue flame which is an indicator that methane is the dominating gas produced (Figure 4).

4. Conclusions

Biogas from chicken manure is of poor quality and it is not advisable to use as a source of fuel. Therefore, night soil due to its similar composition to the chicken manure is not advisable to use as a source of fuel too. Co-digestion of the chicken manure with other substrates that will increase the C/N ratio to a level suitable for biogas production should be fed into the digester, however proper care should be taken to adjust the proportions so that the correct ratio is met. The gas should also be purified before being used in order to avoid health risks to people using it. Biogas from microalgae on the other hand burns perfectly and does not require any purification before it is used. It is therefore wise to opt for the use of biogas from waste water microalgae since it is safe and clean for both human beings and the environment.

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Bacteriological Properties of Commercially Available Fermented Sorghum Beverages (Motoho) Against Selected Spoilage Microorganisms in Maseru

Teboho Lekatsa, Kebitsamang Joseph Mothibe*, `Mamakase Sello, Puseletso Lekhema

Department of Nutrition, Faculty of Health Sciences, National University of Lesotho, Roma 180, Lesotho.

***Corresponding author:** Phone: +266 6308 0372; E-mail: kj.mothibe@nul.ls

Abstract: The fermented sorghum beverage (*Motoho*) is one of the famous traditional beverages found in the markets of Lesotho. It is readily consumed by the entire families including babies in Lesotho therefore its safety is of paramount importance. The objective of the study was to assess the microbiological, physical and chemical characteristics of *Motoho* against potential spoilage strains of *Escherichia coli* and *Staphylococcus aureus* which cause Foodborne Illnesses. The unfermented sorghum beverage (*Lesheleshele*) was used as a control. Selected commercially available samples of fermented and unfermented sorghum beverages were inoculated with *Escherichia coli* ATTC-25922 *and Staphylococcus aureus* ATCC Baa-1026 respectively. Samples were incubated at room temperature, 4°C and 8°C and the presence of bacteria was tested at every 3 hrs. Fermented sorghum porridge showed to have some inhibitory properties against *E. coli* and *Staph aureus* at different incubation temperatures. The findings also showed that there is a significant difference in sugar content and pH of products from different manufacturers. More studies are still needed for the large scale production to set standards in producing healthier and safe beverages.

Keywords: Motoho, Bacteriological properties, spoilage microorganisms and Lesotho.

1. Introduction

The fermented sorghum beverage *(Motoho*) is one of the eminent and nutritious traditional beverages found in the markets of Lesotho [1]. It is readily consumed by the entire families including babies in Lesotho therefore its safety is of paramount importance. High prevalence of diarrheal disease among infant's results from underlying safety problem, and this is critical to the survival and growth of children who are malnourished and maybe HIV positive [2,3]. The objectives of this study was to assess the microbiological, physical and chemical characteristics of *Motoho* against potential spoilage strains of

(a) (b)

Figure 1. Sorghum fermented beverage before (a) and after cooking (b).

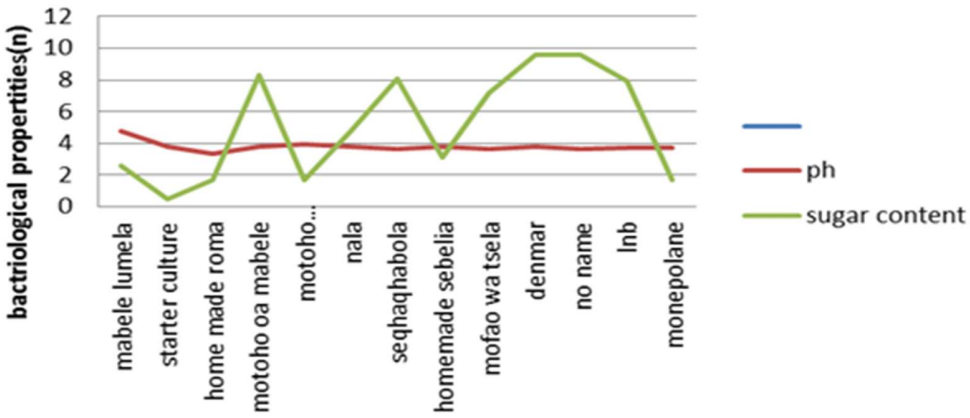

Figure 2. pH and Sugar content of different samples of *motoho*.

Escherichia coli and *Staphylococcus aureus, which* cause Foodborne Illnesses.

2. Materials and Methods

Microbial challenge test in "motoho":

The unfermented sorghum beverage (*Lesheleshele*) was used as a control. Selected commercially available samples of fermented and unfermented sorghum beverages were inoculated with *Escherichia coli ATTC-25922 and Staphylococcus aureus ATCC Baa-1026* respectively [4,5]. Samples were incubated at room temperature, 4°C and 37°C and the presence of bacteria was tested at every 3 hrs.

Table 1: Indicates the results of the samples inoculated with *E coli* under different temperatures

Name of the sample	37°C (Incubator)	Room temperature	4°C Refrigerator
Mabele –lumela	(+3)	Scanty	Scanty
Starter culture	(+3)	(+2)	(+1)
Home- made Roma	(+3)	(+1)	Scanty
Motoho oa mabele	(+3)	(+1)	(+1)
Motoho prepared in the nutrition department	(+3)	(+2)	(+1)
Nala	(+2)	Scanty	No growth
Seqhaqhabola	(+3)	(+2)	(+1)
Home- made Sebedia	(+3)	Scanty	Scanty
Mofao- oa- tsela	(+2)	(+1)	Scanty
Denmar	(+3)	(+1)	Scanty
No name	(+3)	(+3)	(+1)
LNB	(+3)	Scanty	Scanty
Monepolane	(+3)	Scanty	No growth

Table 2: Summary of Gram reaction test

Name of the sample	Shape	Gram Stain
Home made roma	Cocci	+ve
Denmar	Bacilli	+ve
Mofao oa tsela	Cocci	+ve
Starter culture	Bacilli	+ve
LNB	Cocci	+ve
Home made Sebedia	Cocci	+ve
Monepolane	Cocci	+ve
Mabele lumela	Bacilli	+ve
No name	Cocci	+ve
Motoho oa mabele	Bacilli	-ve
Seqhaqhabola	Cocci	+ve
Motoho prepared in nut. Kitchen	Bacilli	+ve

Determination of sugar content in motoho:

The sugar content in motoho was determined using REF-85 Refractometer (Hagavish st, Israel). Distilled water was used as blank.

The end product of sorghum fermented beverage "motoho" (a) Before cooking (slurry) and (b) after cooking (*motoho).*

3. Results and Discussion

Motoho sugar content analysis:

There is a significant difference in sugar content and pH of products from different manufacturers (Figure 1). Fermented sorghum porridge showed to have some inhibitory properties against *E. coli* and *Staph aureus* at different incubation temperature (Figure 2).

Table 1 below shows *Escherichia coli* culture inoculation to various motoho samples and incubation under different temperatures. Generally it can be seen that high growth is observed at high temperatures (37ºC and at room temperature) and lower growth is observed in refrigeration temperature (4ºC). Table 2 Shows samples before inoculation of the pathogen. It can be seen that only one samples shows gram negative bacteria, indicating spoilage.

4. Conclusions

Due to strong experimental evidence that shows that, lactic fermentation inhibits the growth of pathogenic microorganisms, extending shelf life during storage and increases the availability of nutrients of such foods, it is highly recommended that people should include fermented foods in daily meals. It is also recommended that in Lesotho where fermented foods "*motoho*" are already employed as a weaning food, its hygienic preparation and safety should be supported and highly encouraged.

More studies are still needed for the large scale production to set standards in producing healthier and safe beverages.

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Physicochemical and Microbiological Quality Assessment of Different Brands of Bottled Water in Maseru, Lesotho

K.E. Molefe[1], S.B. Mekbib[1,*], L.Williams[1], M.J. George[2]

[1] *Department of Biology, Faculty of Science and Technology,*
[2] *Department of Chemistry and Chemical Technology,*
National University of Lesotho, Roma 180, Maseru, Lesotho.

[*]**Corresponding author:** Phone: +266 6324 2329; E-mail: sbmekbib7@gmail com

Abstract: Water, though vital for life, it is also the commonest route of transmission of a number of infectious diseases. Standard Methods are important for examination of the physicochemical and microbiological quality of water of any source such as bottled, tap and well water. The physicochemical parameters like hardness, alkalinity, pH were examined in comparison with WHO acceptable limits. From the microbiological point of view, water samples C, F, G and H were found to contain *Escherichia coli,* while water samples A, B, D and E were found to contain *Staphylococcus* spp., some of which are opportunistic microorganisms. This indicates poor hygienic water bottling practices, or the absence of microbiological assessment of water from the source. On the other hand, there was no significant variation observed on the physicochemical characteristics of all the different brands of bottled water including the unbottled samples and all the assessed physicochemical parameters were within the WHO standard limits. Results from the microbiological analysis indicate that potential health risks could become a concern in consumption of bottled water in Lesotho. It is therefore recommended that stricter rules should be made and implemented to regularly monitor the bottled water qualities so that the labels of bottled water must include not only the pristine glaciers and Himalayan springs but also the relative concentrations of water quality parameters. Moreover, all the bottled water companies should fulfill the basic water quality standards given by the WHO. Awareness should also be created to the public for either using disinfectants or boiling water before use rather than rely on the belief of purity.

Keywords: Physicochemical, Microbiological, Quality assessment, Bottled water and Lesotho.

1. Introduction

Water is very vital for the existence of all living organisms. This valued resource is increasingly threatened as human populations grow and demand more water of high quality for drinking and for other domestic and economic activities [1]. Though 70% of the earth is covered by water, fresh water accounts 3% of the total water on earth [2]. Majority of freshwater are locked as glacier and polar ice which is difficult to utilize and importing them is costly. As fresh water resources are further stretched to meet the demands of industry, agriculture and an ever expanding population, the shortage of safe and accessible drinking water is estimated to become the major challenge in many parts of the world. There are two major problems with the fresh water of the earth: Fresh water shortage and water quality. Drinking water is derived from two basic sources: surface waters, such as rivers and reservoirs, and groundwater. All water contains contaminants, particularly inorganic contaminants that arise from the geological strata through which the water flows and, to a varying extent, anthropogenic pollution by both microorganisms and chemicals. In general, groundwater is less vulnerable to pollution than surface waters.

Although water is vital for life, it also serves as the commonest route of transmission of a number of infectious diseases. Thus, water quality must be ensured before drinking and the water we drink must be safe. Water quality is defined as the ability of a water body to support all appropriate beneficial uses such as drinking, irrigation or any other purpose, and the determination is typically made relative to the purpose of the water. The quality of water is reflected by various physical, chemical and biological conditions which in turn are influenced by natural and anthropogenic sources. Safe drinking water is defined as water with microbial, chemical and physical characteristics that meet WHO guidelines of national standards on drinking water quality [3]. Water quality parameters like alkalinity, hardness, Dissolved Oxygen (DO), chloride, Total Dissolved Solid (TDS), etc., add to the aesthetic value of water, while parameters like

Figure 1. Five different brands of bottled water.

Figure 2. Well water source, Roma.

ammonia, lead, arsenic, nitrate etc may cause adverse health effects. Water having high or low pH, greater extent of turbidity etc., is objectionable to use. Appropriate amount of chloride content and hardness are desirable but higher content of the same makes the water unaesthetic. Similarly higher content of phosphate, nitrate, ammonia, iron, are undesirable. Some other chemical constituents like arsenic, lead etc. may be toxic.

From microbiological point of view, drinking water should be free from any kinds of pathogens as well as opportunistic microflora. Although there are a number of microorganisms present in water that may pose health threat like *Salmonella* spp., *Shigella* spp., Coliforms, *Mycobacterium* spp. etc. Coliforms are used to assess water quality. Coliforms are gram negative, rod shaped bacteria capable of growth in presence of bile salts and able to ferment lactose at 35-37º C with the production of acid, gas and aldehyde within 24-48 hours. They are oxidase negative and non-spore forming. Coliform organisms (*E. coli*) have long been recognized as a suitable microbial indicator of drinking water quality largely, and thus, their presence in water samples indicates the presence of fecal matter and the possible presence of pathogenic organisms of human origin [4].

The micro-organisms in water are capable of causing various diseases like typhoid (caused by *Salmonella enterica*serovarTyphi), cholera (caused by *Vibrio cholerae*), diarrhea (caused by *E. coli* O157:H7), dysentery (caused by *Shigella dysenteriae*), hepatitis (caused by Hepatitis viruses A, B, C, D, E), etc. According to WHO, unsafe water supply is a major problem and fecal contamination of water sources and treated water is a persistent problem worldwide [3]. Globally, 1.1 billion people rely on unsafe drinking water sources from lakes, rivers and open wells. The WHO has estimated that up to 80% of all sickness and disease in the world is caused by inadequate sanitation, pollution or unavailability of water. Hence it is necessary to purify and disinfect water before it is available for drinking. Many researches and studies have revealed that tap water does not ensure the quality of water. According to the National Water Quality Association, 56% of all people are worried about the quality of municipally treated tap water. With the rising concern on public health, people choose bottled water over tap water.

Bottled water is a term referring to water that is presumed to be processed, packaged and sold in containers or simply bottles. According to the International Bottled Water Association, “Bottled water is a great beverage choice for hydration and refreshment because of its consistent safety, quality, good taste and convenience”. Bottled water can be categorized into Artesian well water, distilled water, mineral water, purified water, sparkling water, well water etc. according to their source and state of purification. From 1988 to 2002, the sales of bottled water globally have more than quadrupled to over 131 million cubic meters annually. One of the main reasons of this is the compromised water quality provided by municipality. Another reason may be the public perception that the bottled water is essentially of high quality.

The public perception and probably the reality is that bottled water is regularly of high quality. This belief is encouraged by publicly reported problem of municipal tap water as well as the public perception of purity driven by advertisements and packaging labels featuring pristine glaciers and crystal clear mountain springs. However, many studies have shown that these beliefs need not always be true. A four-year study conducted by the National Resources Defense Council (NRDC) revealed that about one-third of the samples contained significant contamination, including synthetic chemicals, bacteria and arsenic, in at least one sample, out of more than 1000 samples of 103 bottled water brands tested. The objective of this study was therefore, to assess physicochemical and

microbiological quality of different brands of bottled water in Maseru, Lesotho.

2. Materials and Methods

Water sample sources:

Five available brands of bottled water were used in the study for physicochemical and microbiological assessment. From each of these brands, twelve bottles of water (500ml) were collected (figure 1) from different supermarkets in Roma and Maseru. Tap and well water (figure 2) samples were also assessed for the physicochemical and microbiological quality for comparison. The samples then taken to Biotechnology laboratory, Department of Biology, National University of Lesotho and assessed for quality (physicochemical and microbiological assessment). The samples were kept at 4º C in the fridge when not used.

Water sample analysis:

Physicochemical parameters:

- **pH**

pH was measured by automatic digital pH meter. The pH meter was first calibrated with a standard buffer solution. The glass electrode was washed with distilled water. Then glass electrode was dipped in the beaker containing water sample until the reading was stabilized at a certain point. Then pH reading was noted down.

- **Electrical Conductivity**

The instrument used was digital conductivity meter. The conductivity electrode was dipped in the beaker containing water sample until the reading was stabilized at a certain point. Then reading was noted.

- **Chloride**

Chloride was measured by titration method [5]. About 2 mL of Potassium chromate was added to the sample solution of about 50mL. It was titrated against 0.02N silver nitrate until a persistent brick red color appeared which was the end point of the titration. A blank by placing 50 mL of chloride free distilled sample water

Figure 4. Cream white colonies on MSA.

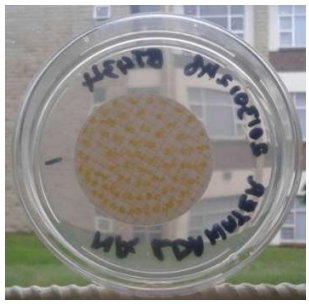

Figure 3. Bacterial colonies after filtration of one brand of bottled water.

was also conducted.

Calculation

$$\text{Chloride (mg/L)} = \frac{(a-b) \times N \times 35.5 \times 1000}{V}$$

Where, a = Volume of titrant (silver nitrate) for sample
b= Volume of titrant (silver nitrate) for blank
V = Volume of the sample in mL
N = normality of silver nitrate

- **Total hardness**

Total hardness was determined by EDTA method [5]. This was done by titrating 100mL of the water sample in a conical flask and adding 1mL of buffer solution with Erichrome Black-T indicator against standard EDTA (Ethylene diamine tetra acetic acid). The solution changed from wine blue at the end point was recorded as positive for metallic cation. Total hardness might be caused by the sum of all metallic cations other than alkali metals and expressed as equivalent calcium carbonate concentration.

$$\text{Total hardness (as CaCO3), (mg/L)} = \frac{\text{mL of EDTA used} \times 100}{\text{mL of sample}}$$

- **Free CO_2**

Free CO_2 in water was determined by using titration method [5]. For this, about 100 mL of sample was taken and 2 drops of phenolphthalein indicator were added. Then the solution was titrated against 0.05N of NaOH from the burette until pink color appeared. The following formula was used to calculate free CO_2 concentration (mg/L).

$$\text{Free } CO_2 \text{ (mg/L)} = \frac{A \times \text{Normality of NaOH} \times 44 \times 1000}{\text{Volume of sample in mL}}$$

Where, A = Volume of NaOH used in mL.

- **Total Alkalinity**

Total alkalinity of water was determined by titrimetric method [5]. About 100mL sample with 2-3 drops of methyl orange was titrated against standard, 0.02N H2SO4. At the end point, the colour changed from yellow changed to pink and this was recorded as positive for alkalinity.

$$\text{Total Alkalinity (mg/L)} = \frac{a \times N \times 1000 \times 50}{\text{Volume of sample in mL}}$$

where, a= Volume of standard H2SO4 consumed in titration

N= Normality of H_2SO_4 used

- **Nitrate-N**

Nitrate content in the water sample was determined by Phenol disulphonic acid method. In this method, about 50 mL of filtrate sample was taken in a porcelain basin and evaporated to dryness. It was cooled and residue was dissolved in 2 mL of phenol disulphonic acid and diluted to 50 mL. About 6 mL of liquor ammonia was then added to develop yellow colour. Then the reading was taken at 410 nm on spectrophotometer. Same procedure was repeated for the standard solution of different concentration and for distilled water. Then the concentration of Nitrate-N was determined from the standard curve obtained by plotting standard value against absorbance.

Microbiological analysis:

Most Probable Number (MPN): The most probable number/ multiple tube fermentation test was used to detect and quantify Coliform bacteria [5]. This test was performed sequentially in three stages: presumptive, completed and confirmed tests.

Presumptive Test: The presumptive Coliform test was done to detect and estimate the Coliform population in the water samples. Volumes of 10ml, 1ml and 0.1ml of each water sample were inoculated into 10ml of lactose broth, and the test tubes were incubated at 37ºC for 48 hours. The tubes were then observed after 24 and 48 hours. The production of any gas within any 24 hours in any of the tubes was recorded as a positive presumptive test while the production of gas during the following 24 hours was recorded as a doubtful test. The absence of gas production after 48 hours of incubation showed a negative test, hence indicating the absence of Coliforms. Coliforms in the test tubes were then expressed as the most probable number (MPN) of Coliforms, which is the count of the number of lactose fermentation tubes showing production of gas following the incubation period. The MPN value was gross referred by matching the results obtained with those in the statistical table provided.

Confirmed Test: The confirmed test was done to prove the presence of Coliforms in the positive and/ or doubtful presumptive tests. Samples from the positive and doubtful presumptive lactose broth tubes were spread plated onto a selective differential medium for Coliforms- Eosine Methylene Blue (EMB) Agar in a discrete manner. The plates were incubated at 37ºC for 24-48 hours and then evaluated for the appearance of typical Coliform colonies with dark centers and metallic sheen.

Completed Test: The completed test was done to confirm the presence of Coliforms in the water samples. Lactose-positive colonies from EMB agar plates were isolated, inoculated into a lactose broth tubes and streaked on nutrient agar slants so that biochemical tests could be performed. For positive completed test, the production of gas and acid in the inoculated lactose broth and the presence of Gram-negative rod-shaped bacteria confirmed the presence of Coliforms in the water samples.

Figure 5. Light pink colonies on EMB.

Membrane Filtration (MF) Technique: Appropriate nutrient or culture media were selected (specifically nutrient agar). The membrane filters removed from the sterile package using the forceps and the membrane filters were then placed into the funnel assembly and the samples were poured into the funnel. The membrane filters were removed from the funnel allowing the liquid to draw completely through the filter and then placed into a prepared nutrient agar in the Petri dishes. The Petri dishes were then incubated at appropriate temperatures (37ºC) for appropriate time (24-48 h) and the colonies were then counted. The colonies from different brands of water were purified and then grown on different selective media (Bacillus Cereus Agar, Brilliant Green Agar, Violet Red Bile Glucose Agar, Eosine Methylene Blue Agar, MacConkey Agar, Mannitol Salt Agar and Salmonella Shigella Agar) for identification.

Biochemical tests: Biochemical tests that include IMViC, catalase, and Gram-staining were performed (figures 3, 4 and 5) to confirm the presence of coliforms and other heterotrophic bacteria in the water samples and also to identify the isolates to genus level.

Data analysis: BM SPSS Statistics version 20 was used to analyse the mean variation between samples for the tested parameters.

3. Results and Discussion

Physicochemical parameters:

On average, water sample H had the highest pH value, then followed by water samples C, G, F, E, B, A and D (Table 1). Water sample H also had the highest value of electrical conductivity, and then followed by C, D, B, A, G, then F and lastly by E (Table 1). Chloride

content, Total Hardness, Free CO_2 and Total Alkalinity were found to be in the range of 0.012-0.120 mg/L, 1.6-30.8 mg/L, 2.2-30.8 mg/L, 3.3-7.5 mg/L and 0.04-0.07 mg/L respectively (Table 1). The water brands A and C showed high electrical conductivity and total alkalinity compared to other water samples (Table 1).

Unbottled water from different sources and all the values are well below the permissible limits of WHO [6]. However, the assessed physicochemical parameters of all the five different brands of bottled water did not correlate with those on the labeling and this shows that most companies just bottle water from

Table 1: Physicochemical parameters of different brands of bottled water and unbottled water from different sources in Maseru, Lesotho.

Water sample	pH	EC (µS/cm)	Chloride (mg/L)	Total Hardness (mg/L)	Free CO2 (mg/L)	Total Alkalinity (mg/L)	Nitrate (mg/L)
A	7.73±0.02	7.64±0.15	0.08±0.04	2.40±0.00	2.93±1.27	3.63±0.12	0.06±0.01
B	7.59±0.03	1.37±0.15	0.05±0.02	1.87±0.23	4.40±0.00	3.37±0.06	0.05±0.01
C	8.09±0.05	89.20±0.69	0.02±0.02	4.93±1.01	12.47±1.27	7.33±0.15	0.06±0.01
D	7.42±0.10	30.83±0.67	0.02±0.02	6.67±1.16	4.40±0.00	3.27±0.06	0.04±0.01
E	7.87±0.02	0.39±0.01	0.04±0.01	29.87±1.01	27.87±2.54	3.83±0.06	0.04±0.00
F	7.90±0.01	0.47±0.00	0.04±0.00	29.60±0.69	29.33±2.54	3.90±0.00	0.05±0.01
G	7.91±0.01	0.48±0.00	0.04±0.01	32.27±1.01	32.67±2.54	3.90±0.10	0.05±0.01
H	8.31±0.02	155.83±1.17	0.02±0.02	4.93±1.01	4.93±1.27	7.40±0.10	0.07±0.00

Key: EC = Electrical Conductivity

Table 2: MPN values of different water samples.

	Volume used (mL)			
Water sample	10	1	0.1	Total Count (MPN/100mL)
F	3	3	3	>11
G	3	3	3	>11
H	3	3	3	>11

Table 3: Number of colonies per brand of bottled water and the colour of those

	Number of colonies (CFU/mL)				
Water sample	Trial 1	Trial 2	Trial 3	Average	Colour of colonies
A	141	77	52	90	White
B	83	45	59	62	White
C	TNTC	TNTC	TNTC	TNTC	White
D	67	57	57	62	White
E	60	59	59	59	White

Table 4: Microbial growth and characterization on different selective media.

		Presence/ Absence of microorganisms		
Water sample	Selective media	Trial 1	Trial 2	Trial 3
A	MacConkey Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
	Mannitol Salt Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
B	MacConkey Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
	Mannitol Salt Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
C	Eosine Methylene Blue Agar	+++ Light pink colonies	+++ Light pink colonies	+++ Light pink colonies
	MacConkey Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
D	MacConkey Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
	Mannitol Salt Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
E	MacConkey Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies
	Mannitol Salt Agar	+++ Cream white colonies	+++ Cream white colonies	+++ Cream white colonies

the source with little or no water quality assessment at all. The results showed no significant variation from different brands of bottled water compared to unbottled water (Table 1).

Microbiological Analysis:

Most Probable Number: The MPN Index and 95% Confidence Limits for various combinations of positive tubes in a 3 tube dilution series using inoculums quantities of 10, 1 and 0.1ml (Table 3.0), it was found that the MPN value of water samples F, G and H was >11 MPN/100ml (Table 2) and this was above the WHO recommendation (6).

Membrane Filtration (MF) Technique: On average, water sample C was found to contain the highest number of microorganisms, then followed by water sample A and then followed by both B and D (Table 3). On the other hand, water sample E was found to contain the least number of microorganisms, and it was also found that these five brands of bottled water contained white colonies (Table 3).

It was found that the microorganisms present in water samples A, B, D and E could only show growth on MacConkey Agar and Mannitol Salt Agar and no growth on Bacillus Cereus Agar, Brilliant Green Agar, Violet Red Bile Glucose Agar, Eosine Methylene Blue Agar and Salmonella Shigella Agar. On the other hand, microorganisms from water sample C could only show growth on Eosine Methylene Blue Agar, MacConkey Agar and no growth on Bacillus Cereus Agar, Brilliant Green Agar, Violet Red Bile Glucose Agar, Mannitol Salt Agar and Salmonella Shigella Agar (Table 4).

Characterization of isolates:

Water samples A, B, D and E were found to contain *Staphylococcus* spp., some of which are opportunistic microorganisms (for example, *S. aureus*) while water samples C, F, G and H were found to contain *Escherichia coli* (Table 5). *E. coli* O157:H7 is one of hundreds strains of the bacterium *E. coli*. Although most strains are harmless and live in the intestines of healthy humans and animals, this strain produces a powerful toxin and thus can cause severe illness [4]. Infection often causes severe bloody diarrhea and abdominal cramps. In some people, particularly children under 5 years of age and the elderly, the infection can cause a complication called hemolytic uremic syndrome, in which the red blood cells are destroyed and the kidneys fail [4].

4. Conclusions and Recommendations

Hence from the above results, it can be concluded that bottled water, although thought to be safe, cannot be relied upon for its safety. All the physicochemical parameters like hardness, alkalinity, pH were within WHO acceptable limits. Nitrates were found in small quantities but within the limits set by WHO. Thus from the physicochemical aspect, the quality of water is good. However, the results on the physicochemical aspect of water quality showed no significant variation from different brands of bottled water compared to unbottled water and the physicochemical parameters of the five different brands of bottled water did not correlate with those on the labeling.

From the microbiological point of view, all the water samples were found to have a potential to cause some illnesses to human beings because water samples A, B, D and E were found to contain *Escherichia coli,* while water samples C, F, G and H were found to contain *Staphylococcus* spp., some of which are opportunistic microorganism. As per the WHO result says, “While much tap water is indeed risky, having compared the available data, we conclude that there is no assurance that bottled water is any safer.” Similar is the conclusion of this study, that there is no assurance that since water comes out of a bottle does not mean it is free from contamination.

It is therefore recommended that stricter rules should be made and implemented to regularly monitor the bottled water qualities so that the labels of bottled water must include not only the pristine glaciers and Himalayan springs but also the relative concentrations of water quality parameters. Moreover, all the bottled water companies should fulfill the basic water quality standards given by the WHO. Awareness should also be created to public for either using disinfectants or boiling water before use rather than rely on the belief of purity.

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Deploying Novel Forms of Nisin to Control Listeria Monocytogenes in Food Industry

Teboho Lekatsa*, Mothibe Kebitsamang Joseph, `Mamakase Sello

Department of Nutrition, Faculty of Health Sciences, National University of Lesotho, Roma 180, Lesotho.

***Corresponding author:** Phone: (+266) 6305 1430; E-mail: tk.leekatsa@nul.ls

Abstract: There is growing consumer awareness of the link between diet and health. Consumers are more concerned about the synthetic chemicals used as preservatives in food now-a-days, and there is resulting trend towards less processed food. These untreated foods can harbour dangerous pathogens which can multiply under refrigeration and without oxygen. Lantibiotics are post-translationally modified antimicrobial peptides, of which nisin A is the most extensively studied example. Nisin is a natural, toxicologically safe, antibacterial food preservative. Here we address this issue by assessing the ability of nisin A and nisin V to control Listeria monocytogenes EGDe in two commercially available milk products. The efficacy of the nisin peptides in chocolate milk resulted in significant reduction (over 1 log) in listerial numbers for nisin V after 24 hrs. In cottage cheese, after 48 and 72 hours no listerial cells were detected in the nisin V containing cottage cheese sample while low cell numbers (7×10^2) were detected in the nisin A samples This analysis revealed that nisin V was more effective than Nisin A with respect to being used as anti-Listeria food preservative. Further studies will be essential to find the optimum pH and sodium chloride conditions to control Listeria in particular target food products.

Keywords: Nisin, anti-microbial activity, *Listeria monocytogenes,* natural preservative, Lanibiotics

1. Introduction

Nisin (figure 1) is a low molecular weight antimicrobial protein produced by certain strains of *Lactococcus lactis* [1] . It is a member of a large group of bacterially produced peptides or bacteriocins that are active against other bacteria and to which the producer has a specific immunity mechanism. Production of bacteriocins by lactic acid bacteria (LAB) have been the focus of much attention as a result of their generally regarded as safe (GRAS) status, potential commercial applications and the high prevalence and pivotal roles that this group of b Though the LAB bacteriocins represent a heterogeneous group of molecules, two major groups have been defined; i.e. those that are modified to incorporate unusual residues including lanthionine and methyl lanthionine (class I or lantibiotics) and those that are unmodified (class II). Lantibiotics are produced by, and act mainly against Gram-positive bacteria, including nosocomial pathogens such as MRSA, *enterococci* and *Clostridium difficile*, but also food spoilage and pathogenic bacteria such as *Bacillus cereus, Staphylococcus aureus* and *Listeria monocytogenes* plays in food applications [2]. The consumption of food that has been formulated with chemical preservatives has heightened consumer concern and created a demand for more “natural” and “minimally processed” food. Hence, there has been a great interest in bacteriocins as potentially safe and natural food preservatives and additives. . While research into bacteriocins has been underway for decades, it is only recently that genetic engineering investigations have led to the discovery of improved lantibiotic peptides including nisin [3], mersacidin [4] and nukacin ISK-1[5]. Importantly, in the case of nisin, a number of derivatives were found to have increased activity against Gram-positive pathogens including *Listeria monocytogenes* and *Staphylococcus aureus* [3]. This is particularly important as *L. monocytogenes* is the causative agent of listeriosis, one of the most significant food borne diseases in industrialized countries. Understandably, the food manufacturing industry is very concerned with *L. monocytogenes* because of its potential for disease and its capacity to survive and grow in a wide variety of food substrates and enviromental conditions, including refrigeration.
Worryingly, increases in the incidence of Listiriosis were observerd in many EU member states in recent years [5]. Many of these is because *L. monocytogenes* can survive in stressful enviroments, including refrigeration temperatures, low pH and high salt concentrations [6].

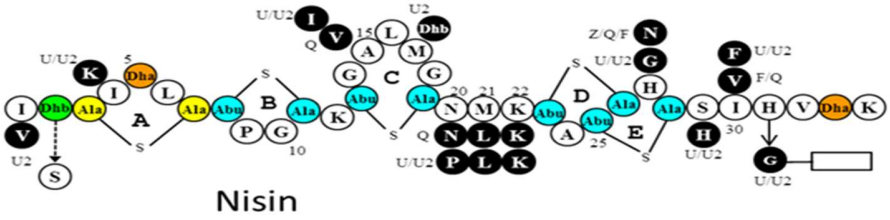

Figure 1. Structure of nisin A. Ala-S-Ala, Lanthionine; Abu-S-Ala, ß-methyllanthione; Dha, dehydroalanine; Dhb, dehydrobutyrine. (ß-methyl)lanthionine rings are labelled A-E. (Kuipers O.P et al. Biol. Chem. 1995; 270: 27299-27304).

2. Materials and Methods

Bacterial strains and growth conditions:

L. lactis strains were grown in M17 broth supplemented with 0.5% glucose (GM17) or GM17 agar at 30˚C. *S. aureus* and *Listeria* strains were grown in Brain Heart Infusion (BHI) or BHI agar at 37˚C. Antibiotics were used where indicated at the following concentrations: kanamycin 80µg ml^{-1}on *S. aureus* and chloramphenicol 2.25µg ml^{-1}, on *Listeria monocytogenes*.

Nisin Purification:

Lactobacilus lactis NZ9700 or the mutant Nisin strain of interest was sub cultured twice in GM17 broth at 1% at 30°C before use. Two litres of modified TY broth were inoculated with the culture at 0.5% and incubated at 30°C overnight. The culture was centrifuged at 7,000 rpm for 15 min. The cell pellet was resuspended in 300 ml of 70% isopropanol 0.1% TFA and stirred at room temperature for approximately 3h. The cell debris was removed by centrifugation at 7,000 rpm for 15 min and the supernatant retained. The isopropanol was evaporated using a rotary evaporator (Buchi) and the sample pH adjusted to 4 before applying to a 10g (60ml) Varian C-18 Bond Elute Column (Varian, Harbor City, CA) pre-equilibrated with methanol and water. The columns were washed with 100 ml of 20% ethanol and the inhibitory activity was eluted in 100 ml of 70% IPA 0.1% TFA. 15 ml aliquots were concentrated to 2 ml through 0µg ml^{-1}on *S. aureus* and chloramphenicol 2.25µg ml^{-1}, on *Listeria monocytogenes*.

3. Results and Discussion

Determination of Salt and pH limits of L. monocytogenes:

High levels of this bacteriocin have been shown to completely eliminate *L. monocytogenes* in soft cheeses within periods as short as 24 h [7]. Thus, to assess potential combinatorial effects using nisin V and nisin A in a food setting, initial investigations on the growth and survival of *L. monocytogenes* EGDe and *S. aureus* Xen 29 at different pH levels and salt concentrations were assessed. The bacteria were first plated on BHI agar at a range of different concentrations of salt (2, 4, 6, 8 and 10%). The maximum salt concentration that permitted *L. monocytogenes* growth after 24hr

Table 2. Results of agarose-based deferred antagonism assays against S. aureus Xen29 with purified nisin A and nisin V under various conditions

Chemical and Physical test parameters	Nisin WT (zone diameter in mm)	Nisin V (zone diameter in mm)	%WT
NaCl (%)			
0	11.58667 ±0.18	14.36333 ±0.14	124.1
2	7.37 ±0.38	10.29 ±0.03	139.6
4	7.066667 ±0.65	10.17333 ±0.53	144.1
6	9.876667 ±0.05	12.57333 ±0.24	127.3
Temp (˚C)			
4	N/G	N/G	
RT	13.47 ±0.35	14.83667 ±0.02	110.1
30	14.61667 ±003	14.67333 ±0.01	100.1
37	14.10667 ±0.14	14.47333 ±0.02	102.6
pH			
4.5	11.93 ±0.03	12.85333 ±0.24	107.7
7.5	12.73667 ±0.21	14.72333 ±0.22	115.6
8	13.03 ±0.22	14.95333 ±0.45	115.6
10	14.54667 ±0.49	15.62 ±0.14	107.4

Table 1. Effect of NaCl and pH on the growth of *L. monocytogenes* EGDe and *S. aureus* Xen 29

	NaCl concentration					pH		
	2%	4%	6%	8%	10%	4.5	7.5	10
L. monocytogenes EGDe	√	√	√	X	X	✓	✓	x
S. aureus Xen29	√	√	√	√	√	✓	✓	✓

incubation at 37˚C was 6% (Table 1). This is in agreement with previous studies that indicate higher a concentration of salts limits the growth of the bacteria [8].

Assessment of nisin V and nisin A in combination with NaCl or pH via agarose assays:

Results of deferred antagonism assays with *L. monocytogenes* EGDe across NaCl concentrations ranging from 0% to 6% indicated that nisin V exhibited its greatest inhibition (147.5%) when compared to nisin A at 2% sodium chloride (Table 2).

4. Conclusions

Listeria monocytogenes continues to be a concern to food industries because of its ability to grow at refrigeration temperatures. It is causative agent of Listeriosis, one of the significant food borne disease for humans. Thus, the novel approaches used to prevent the contamination of this pathogen in food is the use of bacteriocin-producing lactic acid bacteria. In this study we demonstrated that, with added hurdles it shows significant antimicrobial activity over nisin A with respect to controlling *Listeria monocytogenes*. In recent years, there has been a particular interest on the potency of nisin V against Gram-positive pathogens including *L. monocytogenes* [9,11]. In this study we demonstrated that, with added hurdles it shows significant antimicrobial activity over nisin A with respect to controlling *Listeria monocytogenes*. Further studies will be essential to find the optimum pH and sodium chloride conditions to control Listeria in particular target food products. Notably, these studies employed a high initial inoculum (1 x 10^6 cfu ml^{-1}) which is much higher than would be expected in a food processing plant (~20 cfu/g) and were carried out at room temperature, a temperature that would not be part of normal manufacturing processes.

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Language, Science and Translation within a Socio-Developmental Context in Lesotho

Mosisili Sebotsa

Department of French, National University of Lesotho, Roma 180, Lesotho.

Phone: (+266) 5850 5557; E-mail: sebotsa@outlook.com

Abstract: In the world of industrialisation and mass production, technological designers invent ideas and products to satisfy human needs while in various technical domains specialists communicate in unison as they employ a well-established European technical jargon intelligible only to the initiated. However, in the African context, due to absence of cultural equivalence and differing educational backgrounds, highly technological concepts are not always easy to communicate to the ultimate consumer, the common man. This is exacerbated by the fact that vernacular languages are not always used at all levels of education to teach scientific and technological studies and the fact that existing scientific terminology is not sufficiently employed by the local scientific community. In Lesotho, this situation has demarcated and established a visible diametrical polarity between the specialist and the consumer (the common person), between the literate and the illiterate. The study endeavours to show the importance of language and terminology development in a predominantly monolingual society. It demonstrates how use of English as the only medium of instruction at all levels of education and social development limits the development of Sesotho in techno-scientific terminology. It manifests how this practice impairs capacity building initiatives and how it hinders collaboration and community participation in the overall development of the country among semi-literate and illiterate consumers. It further proposes a mechanism of how to create scientific terminology. Lastly, it encourages collaboration among linguists, technical translators and scientists with the aim to attempt a usable but precise Sesotho techno-scientific lexicon in various scientific fields.

Keywords: Language, Translation, Techno-scientific terminology, Cultural equivalence, Creation of scientific terminology.

1. Introduction

The importance of language in the human development at any point in time cannot be overemphasised. Without language, sharing of scientific information and knowledge would be almost impossible since all scientific communication can only be accomplished within the linguistic competences of the communicator as well as that of the recipient of the scientific information. Thanks to translation as a linguistic bridge that fills the gap between cultures, scientific information has been communicated across different cultures with the same result and impact thus affording technological designers in countries that invent and export ideas and concepts a chance to be understood beyond the borders of their own culture. Concomitantly, it has also allowed importing cultures access to information which would otherwise be conceptually inaccessible as it does not exist in the target culture.

The present paper endeavours to demonstrate how important language is in the process of social development, especially in semi-literate or illiterate communities in Lesotho. It strives to show how use of English as the primary medium of instruction impacts on the development of Sesotho in techno-scientific terminology, how it affects capacity building initiatives, collaboration and community participation in the overall national developments. The paper advocates for change of attitude towards use of Sesotho as a parallel medium of instruction most especially in socio-developmental issues. The paper further strives to propose mechanisms through which scientific terminology can be created in Sesotho and encourages coordinated collaboration among linguists, technical translators and scientist with the aim to attempt a usable but precise Sesotho techno-scientific lexicon in various scientific fields.

2. Translation and Acquisition of knowledge

Most African countries are predominantly marked by historical diversity and multilingualism. To these characteristics is added another factor - use of European languages such as English, French and Portuguese as either a national medium of instruction at all stages of education or a unifying lingua-franca among the many ethnic groups. Whatever the socio-

historic reality of any given people, the main function of any language remains the same - to communicate. However, Klikenberg [1] clarifies that even as a communication tool, language has to respond to various human needs. In mathematico-scientific fields, it employs precise and straight to the point terminology to express clear cut notions while in humanities, it becomes abstract and colourful as it expresses reality in figurative terms. In the same logic, Baboya [2] identifies three functions of language - to describe the world around man, to express things and to argue. To these functions, I would like to propose the fourth function which is in line with the objectives of the present study - to register information. What makes this function important is the fact that language is the tool through which all learnt information, be it cultural, artistic, historical, developmental or techno-scientific, is transferred and stored in the memory. It is also the tool used to recall information and re-express it. This view is shared by Ademowo [3] who argues that language is so essential to human existence, education and socialisation that such abstract aspects of culture and identity as tradition, proverbs, science and mathematics, etc. are conceived and passed from generation to generation through language.

It is in this context that I advocate for use of Sesotho in techno-scientific development issues and education as recommended by UNESCO [4] and Ademowo [5]. I argue and hypothesize that it can contribute towards the development of Lesotho only if it is undertaken with utmost preparation, a wider, longer and sustainable vision that can be upheld and defended by the majority of the stakeholders because, like any other revolutionary policy, it will meet with resistance at its introduction and because for some people, the notion of being educated is almost always associated with the ability to speak the English language. This argument is validated by the fact that, according to Lesotho National Development Corporation (LNDC) [6], Lesotho boasts the advantage of being a predominantly monolingual and monocultural since Sesotho speaking population constitutes 99.7% while the 0.3% includes Nguni dialects, Europeans, Asians and other African expatriates. It is therefore my argument that this advantage has not been fully exploited and that there is no point in putting English in the forefront in all socio-developmental issues and particularly in earlier years of education, since the majority of the population is more conversant in Sesotho than it is English. As for use of Sesotho in education, I base my argument upon the experiences of Sesati *et al* [7] and Setati and Moschkovich [8] who conclude that, in their early day of schooling, the main challenge in learning mathematico-scientific concepts was use of a foreign language (English) as the only medium of instruction as they not only had limitations but were forced to memorise concepts instead of understanding them. Thus, in the case of Lesotho, use of Sesotho would render these concepts accessible since in their conceptual and abstract forms, mathematico-scientific concepts require mastery of a complex and demanding technical language, most especially if the language of instruction is foreign to both the student and the instructor.

To remedy this problem, I propose an elaborate and well-researched language and translation policy built around key economic and socio-developmental areas such as agriculture, education, arts, trade and industry, commerce, communication, provision of techno-scientific services, etc. The second step involves a well-funded, coordinated collaborative translation work among technical translators, specialists and educators in these key educational, economic, techno-scientific and socio-developmental areas.

3. Materials and Methods

To put my argument and hypothesis to test, I conducted a quantitative and qualitative interview to 50 primary school teachers in 20 primary schools. The teachers were bilingual with Sesotho as L1 and English L2. The choice for primary schools teachers is justified by the fact that their early primary schooling was under a bilingual schooling system - that is a system where the mother tongue language is used as a medium of instruction while the L2 (English) is learnt later on. This meant they could relate with use of Sesotho (L1) as a primary medium of instruction up to at least Standard 4 or 5 (Grade 4 or 5). The aim of the exercise was to validate the feasibility of bilingual schooling. They were supposed to respond to a number questions indicated in Table 1 with four (4) responses listed below. The responses are coded in the four columns according to the opinion given by the teachers: 1. = *Most definitely;* 2. = *Yes;* 3. = *Maybe;* 4. = *Not at all*.

Development of scientific terminology in Sesotho:

Data has been collected from the below mentioned documents as proof of the fact that they are well established in the Sesotho lexicon. In accordance with the one of the objectives of the present paper and based on the fact that, in African issues, one cannot neglect orality as a vehicle of intangible cultural heritage, I call upon informer-experts chosen on the basis of their specialty:

- Sesotho-English Dictionary (1893) et (2000)

English	**Sesotho**	**Gloss**
hearing aids [N1 + N2]N	*lithusa-kutlo* [N1 + N2] N	helpers hearing
thermometer	*sebala-mocheso* [N1 + N2] N	Counter heat

Questions asked		1	2	3	4
1.	*Do you think use of L1 (mother tongue language) in earlier stages of schooling has any advantages at all over use of a foreign language as the medium of instruction?*	*45*	*5*	*0*	*0*
2.	*Do you think bilingual schooling would improve understanding of scientific concepts for children?*	*25*	*20*	*5*	*0*
3.	*Would it be helpful to have Sesotho books in the teaching and learning of science and technological studies?*	*35*	*10*	*5*	*0*
4.	*Do you think use of L2 (foreign language - English) as the only medium of instruction at all levels of education has advantages at all over use of L1 (mother tongue language -Sesotho)?*	*10*	*10*	*20*	*10*
5.	*Do you think use of English in all socio-developmental issues affects community participation?*	*35*	*15*	*0*	*0*
6.	*Do you think a collaborative translation work can help Sesotho become a scientific language?*	*50*	*0*	*0*	*0*
7.	*Do you think availability of scientific information in both English and Sesotho can enable communication among scientists and common people?*	*50*	*0*	*0*	*0*
8.	*Is there need for a policy on bilingual schooling built around key economic areas?*	*40*	*5*	*5*	*0*

- Leselinyane la Lesotho

Informant-experts

- Contractors
- Retired Sesotho Teachers

The analytical approach taken in this study is the one used by Dispaldro et al. [9], who postulate from the Canadian point of view that the dominance of English over French has created a considerable linguistic imbalance in favour of English. In order to bridge the linguistic gap in French in general, they propose a techno-scientific model of lexical creation as a morphological borrowing based on the nominal and syntagmatic structure of the source language but adapted in accordance with the morphosyntactic elements of the target language.

There are a number of reasons for opting for a literal techno-scientific translation but only four have been identified as pertinent in as far as Sesotho is concerned.

- The transcription of the source language model in accordance with the morphosyntactic rules of Sesotho allows for immediate understanding of the material object being referred to by the concept;
- It is a terminology creation method that allows a language to quickly make up for its terminology insufficiency when a new concept is introduced into the Sesotho culture;
- This transcription renders technical terminology accessible and semantically transparent;
- It showcases the linguistic tools, the vitality of Sesotho as well as its capacity to adapt to new linguistic situations.

In the present study, literal techno-scientific translation is studied as a form of naming and therefore, as a contribution towards the lexical expansion of Sesotho, especially in scientific domains.

4. Morphosemantic analysis

Naming by exact reproduction of the source language model:

In the first category, neoclassical compounds such as *thermostat, ecosystem, autograph, thermometer,* etc., maintain the [N1 + N2]N construction but the constituents are inversed in a manner that renders them semantically transparent, in accordance with the morphosyntactic rules of Sesotho as it can be observed below:

The morphosemantic analysis of the term *sebala-mocheso* “reader heat = thermometer” [N1 + N2]N,

clearly shows that the two constituents forming the compound noun are a result of a derivative process whereby the determinant on the left (N1) is derived from the verb *ho bala* "to count/calculate" by adjoining the prefix *se-* (C7).[*] The verbal suffix only remains in its place in order to function as an indicator that the word in question is an agent noun even though the word does not exist in isolation. In the second constituent acting as the modifier, *mocheso* "heat" (N2) is derived from the verb *ho chesa* "to heat" whereby the prefix *mo-* C3 is added to the root and the suffix *-a* disappears to allow *-o* to function as a nominal suffix.

The decomposition of this neoclassical compound has rendered it semantically transparent to the common man so much so that if in English one has to peruse the dictionary to understand that a thermometer is actually *an instrument for determining temperature; especially: one consisting of a glass bulb attached to a fine tube of glass with a numbered scale and containing a liquid (as mercury or colored alcohol) that is sealed in and rises and falls with changes of temperature* and that etymologically speaking, the term is derived from *therm + o + meter* (MWUD[†]), Sesotho names the apparatus in a clear and simple manner that helps make it comprehensible to both the initiated and the common man in that one understands that we are talking about an apparatus that *determines the amount of heat.*

Naming by lexical innovation:

This process consists in translating loosely to obtain a new term that does not resemble the English word in any manner. I consider these terms as having been innovated if they did not exist before the introduction of the material object to which they refer, if they were rendered polysemic and if Sesotho dug into its resources of lexical creation in order to respond to bridge the evident techno-scientific lexical gap brought by new realities that were not part of the indigenous culture.

English	Sesotho	Gloss
Radio	*seea-le-moea*	thing that goes with air
aeroplane	*sefofane*	flying thing

Seea-le-moea "thing that goes with air = radio" is a well-established phrasal noun in Sesotho even though research leads to hypothesise that originally, it may have been coined to translate *wireless*, British English for radio. While *seea-le-moea* is understood to refer to a radio, the phrasal noun *seea-le-moea-pono* "thing that goes-with-air-vision = television" was derived probably after 15th September 1988, which is the year of establishment of Lesotho Television (LTV). The latter is an abnormal assemblage derived from a syntactic sequence that was recursively transformed into a lexical unit, where *pono* "vision" is added to the phrasal noun to form an even more complex assemblage. From a morphosemantic point of view, the lexical freezing of this combination isolates *seea-le-moea* "radio" and makes it a single independent noun while *pono* "vision" constitutes another single independent noun. The assemblage "radio + vision = television" makes it possible to understand the combination a television as a radio on which you can see images.

5. Conclusions

While the present study does not advocate for total abolition of English in education in Lesotho, a few observations have been made regarding bilingual learning and teaching of techno-scientific concepts. Firstly, some students lose interest in school not because they are below average but because they struggle with the L2 (English) which is used as the only medium of instruction. Secondly, use of Sesotho through translation of key concepts would give all students a fair chance in education since examinations would be set and taken in a language they fully understand. Thirdly, use of Sesotho would result in increased parent participation in issues relating to children's education. It is probable that these observations be applicable across other fields than science and mathematics. On this basis, it is recommended that the Ministry of Education conduct a focused study on bilingual learning as an alternative to English medium teaching or total immersion system that is currently used by private and semi-private schools.

As for techno-scientific terminology development, it is evident that a great deal of translation work in collaboration with specialists in key techno-scientific and economic areas such as agriculture, education, trade and industry, commerce, communication, provision of techno-scientific services, etc. is imperative. The task that concerned authorities, project managers, linguists as well as language users in general are faced with is to allow the language to change and develop concomitantly with new realities surrounding it, whether it be through techno-scientific borrowing of words from other languages, deriving them from the already existing lexicon or coining new terms. This would have trickle-down effects that would fast track the pace of development by increasing the rate of community participation since most people would be talking about the same concepts with minimal ambiguity. Establishment of a technical lexicon in all

[*] C8 represents (Class 8) of the noun classes of Sesotho.
[†] Merriam Webster Unabridged Dictionary.

fields of specialty would also simplify access to information by specialists and researchers. Considering that Lesotho is a monocultural state, the probability of attaining success in developing scientific terminology through translation may be relatively high, however, it is imperative that there be political will, well-articulated language and translation policy, ample funding and the desire from participating stakeholders to collaborate on such a monumental task as scientification of Sesotho.

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Screening and Extraction of Essential Oils from Different Indigenous Non-food Plants for Detergent Production

Thabiso Letseka, Mosotho J. George*

Department of Chemistry and Chemical Technology, National University of Lesotho, Roma 180, Lesotho.

***Corresponding author:** Phone: (+266) 5221 3502; E-mail: jm.george@nul.ls/maluti2005@gmail.com

Abstract: In this study, an alternative plant oil is investigated for substitution of pine oil, which is the most expensive ingredient in pine gel detergent. Firstly a headspace sampling technique known as BID-SDME was optimized for the initial screening for presence of essential oils in the plants as to compare their profiles with that of the commercial pine oil. The parameters optimized were as follows: use of 1 µL heptadecane with 0.5 µL of an air-bubble as an extraction solvent, 55 °C sampling temperature, 15 minutes sampling time and 1500 µL sample volume. Following the screening of the potential plants, oil was extracted from different locally growing non-food plants using a modified steam distillation for comparison of oil content. Of the screened plants, *Tagetes minuta* known locally as either *monkhane* or *lechuchutha* resulted in the highest yield of 0.83 -1.35% while sewage algae and pine leaves resulted in yields of 0.28 - 0.44 and 0.54 - 0.97% (v/m) respectively. *Tagetes minuta* oil was then used for detergent preparation. However, the detergent could not set the same way as the pine gel counterpart and displayed higher CMC (0.002219 mol/L) compared to that of the pine gel 0.001691 mol/L demonstrating a somewhat lower detergency. Despite these challenges, *T. minuta* still demonstrated a potential that will lead to improved profit margin should the optimization be carried out further.

Keywords: Pine gel detergent, pine oil, *Tagetes minuta* oil, Critical Micelle Concentration, fluorescence.

1. Introduction

As a means of counteracting unemployment in developing countries like Lesotho, individuals tend to go in the commercial sector and become entrepreneurs. However capital investment still remains a daunting challenge. Detergent production on a small scale is one of the processes that do not require complex capital investments as it generally involves simple mixing of reagents. Some of the reagents are industrially produced and are cheaper while others are obtained directly from nature and get to be very expensive. For instance, pine oil is an ingredient of Pine gel detergent and it is produced as a by-product in wood production and this makes it very expensive thus lowering profit margins in the detergent production.

This was a problem experienced by one of the local detergent manufactures in Leribe and the basis of the study was to help find a solution to the problem. Pine gel is an effective, fast working, environmentally friendly and most versatile all-purpose disinfectant, detergent and sanitizer that is made from pure and natural pine-oil that when applied leaves behind a long lasting fresh pine forest fragrance due to the presence of β-Phellandrine and β-Pinene monoterpenes that result in a pleasing aroma [1]. Pine gel is usually formulated by mixing controlled amounts of surfactant e.g linear alkyl benzene sulphonic acid then neutralizing with caustic soda then adding pine oil. Mixing linear alkyl benzene sulfonic acid with caustic soda solution neutralizes the acid hydrogen of the sulfonic acid with the hydroxide ion in the caustic soda solution resulting in linear alkyl benzene sulfonate salt. This compound has two parts attached chemically; one is the sulfonate which is hydrophilic and attaches to water molecules and the other is the linear alkyl benzene group that attracts the pine oil. This ability to attract both water and the pine oil is what results in a gel.

The aim of the study was to find a cheaper and easily accessible alternative for pine oil (the most expensive reagent in the pine gel detergent) from locally available non-food plants while still maintaining similar properties in the detergent. The plant *Tagetes minuta* locally known as *lechuchutha* or *Tagetes minuta*, blackjack in English, belongs to the Asteracae family. The species is an invasive weed and aggressively colonizes disturbed areas and fallow farmlands [2]. The plant in Lesotho is reported to be used as an insecticide and applied to crops mixed with other local plants. The plant also possesses anti-microbial properties which are

similar to those that pine oil possesses and this plant oil may serve as alternative to pine oil [2].

Since there is a direct interaction between the oil and the surfactant molecules, it is crucial to determine the efficiency of the newly produced detergent in comparison to that of pine gel. This is usually determined by the critical micelle concentration. Micelle are spontaneously formed aggregated units with the hydrophobic ends forming the core while the hydrophilic ends form a surface hydrated by water molecules [3]. It is the presence of micelle that results in the detergency. Critical concentration is defined as the minimum concentration of molecules at which the intermolecular hydrogen bonding, micelles, or other aggregates start forming. The value of the CMC can be determined by the change in the physicochemical properties of the surfactant solution as the surfactant concentration increases. Ideally low CMC values of surfactants are favorable [4].

The 1:3 ratio is one of the commonly used procedures for the CMC determination, it was initially used for determination of pure micellar solutions but has also found application in mixed surfactant systems. This method makes use of the dependence of the fluorescence vibrational structure of pyrene on solvent polarity. This method makes use of the intensity of the ratio of the 1st and 3rd vibrational peaks hence the name (1:3 ratio). Below the CMC the pyrene 1:3 ratio value corresponds to a polar environment of the water molecules; as the surfactant concentration increases the pyrene 1:3 ratio decreases rapidly, indicating that the pyrene is sensing a more hydrophobic environment since it is will be enclosed into the core of the micelle. Above the CMC, the pyrene 1:3 ratio reaches a roughly constant value because of the incorporation of the probe into the hydrophobic region of the micelles [5].

2. Materials and Methods

Plant harvesting and screening of plant volatiles:

Plant samples were harvested by plugging off the plant leaves the same day of the extraction to prevent loss of plant volatiles that may occur during the storage of the plant and were washed thoroughly with water. A weighed mass of plants and a measured amount of oil was placed in a vial and tightly closed to prevent any plant loss during the extraction. The extraction of plant volatiles was achieved through the BID-SDME method initially described by Williams et al [6] using 1 µL heptadecane with 0.5 µL of an air-bubble as an extraction solvent, 55 °C sampling temperature, 15 minutes sampling time and 1500 µL sample volume.

Essential oil extraction:

Plant samples were harvested by plugging off the plant leaves the same day of the extraction to prevent loss of plant volatiles that may occur during the storage of the plant and were washed thoroughly with water. Plant leaves were weighed and ground using a blender and added to a distilling flask then water was added for extraction and placed on a heat source. After a 3 hour extraction time elapsed, diethyl ether was added into the receiving flask to allow further separation of the oil from the water. The ether was then evaporated and oil was obtained.

GC-MS Analysis:

A Shimadzu QP 2010 GC-MS fitted with a Zebron ZB-5MS column (30 m x 0.25 µm ID x 0.25 mm film thickness) was used for the analysis. One µL of each oil sample was directly injected into the GC at a split ratio of 300:1 at an inlet temperature of 250 °C. Similar oven conditions as those of GC were applied with few

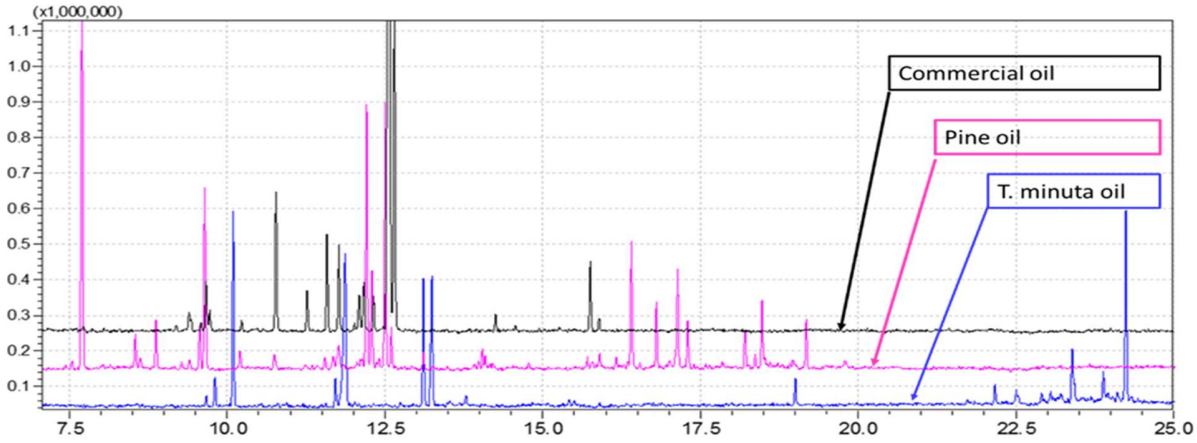

Figure 1: Total ion GC-MS Chromatogram of extracted oils (a) *Tagetes minuta* (b) pine oil.

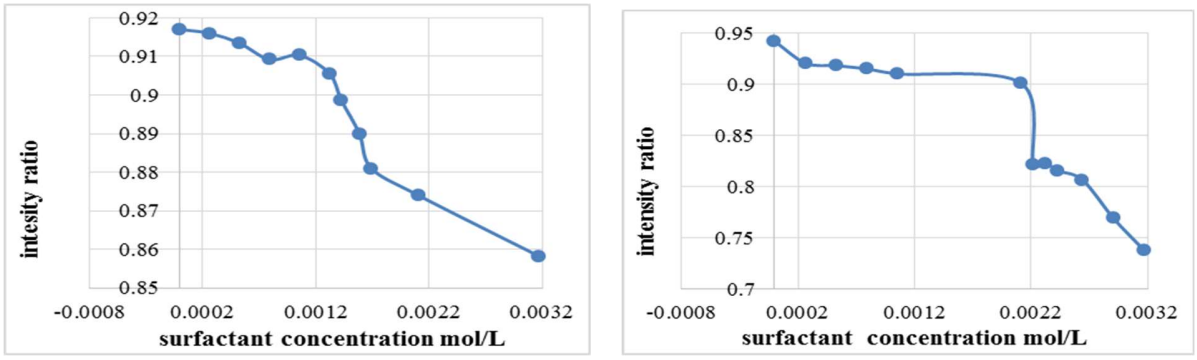

Figure 2: Graphs of fluorescence intensity versus surfactant concentration for the determination of critical micelle concentration. (A) Pine Gel, and (B) *Tagetes minuta*..

variations as follows. Helium was used as a carrier gas at a flow rate of 1 ml/min. For MS detection, ionization was achieved by electron impact at 70 eV and the scan range was from 50 – 350 m/z. The compounds were identified using the NIST library.

Fluorescence analysis:

Fluorescence measurements were performed on a Shimadzu RF-1501 Spectrofluorophotometer. Fluorescence emission spectra of a number of surfactant solutions containing 50 µL of 0.025 M of pyrene were recorded using an excitation wavelength of 335 nm, and the intensities I1 and I3 were measured at the wavelengths corresponding to the first and third vibronic bands located near 373 and 384 nm. The ratio I is the so-called pyrene 1:3 ratio. All fluorescence measurements were carried out at 25.0 ± 0.1 °C. The excitation and emission slit width were adjusted to 10 nm and the scan speed was fast with high detection sensitivity.

3. Results and Discussion

GC-MS analysis:

Figure 1 shows only seven major compounds in Tagetes minuta and it is in accordance with the one in literature. Pine oil chromatogram shows more peaks when compared to that of *Tagetes minuta*, indicating that pine oil contains more compounds than Tagetes minuta despite the latter's oil being coloured while that of pine tree is colourless.

Properties of the prepared detergent:

Tagetes minuta gel is slightly thinner than pine gel and this is may be due to presence of fewer essential oils in *Tagetes minuta* while pine oil has more and this was seen from the chromatograms. It has yellow in color while pine gel colorless without any dye used post processing. It takes a longer time to set however upon addition of a few drops of pine oil the setting process takes a shorter time. It has also a very strong scent that is characteristic smell of the *Tagetes minuta*

Detergent efficiency determination by CMC method:

The plots in figure 2 illustrate the efficiency determination by fluorescence of both detergents from the inflection points. Pine gel had a lower CMC value of 0.001691 mol/L while *Tagetes minuta* had a CMC value of 0.002219 mol/L. This is a reflection that pine gel has a better detergency than *Tagetes minuta* gel, however this has not compromised detergency of the product.

4. Conclusions

Plant oils from algae, pine and *Tagetes minuta* were extracted; *Tagetes minuta* oil (with higher oil yield) was used in the detergent preparation. The efficiency of the new detergent was determined in comparison to that of the pine gel and was found to be lower than that of pine gel.

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Wastewater Stabilization Pond Technology: Effectiveness and Efficiency at the Ratjomose Sewage Treatment Plant, Maseru, Lesotho

S.E. Aiyuk*, R.N. Molomo, A.M. George

Department of Environmental Health, National University of Lesotho, PO Roma 180, Lesotho.

***Corresponding author:** Phone: +266 2234 0601, 5945 0338; E-mail: se.aiyuk@nul.ls

Abstract: The study was carried out to determine performance and efficiency of stabilization ponds at Ratjomose sewage treatment plant in removal of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and total phosphorus from wastewater. Factors that may affect the plant's efficiency and effectiveness were also determined. Grab samples of wastewater from the influents and effluents of facultative ponds (F1 and F2) and maturation ponds (M1 and M2), were analysed according to standard analytical procedures for water analysis. Facultative pond 1 showed 40%, 93.3% and 85.1% efficiency in removal of BOD, TSS and Total phosphorus respectively. Facultative pond 2 showed -233.5%, -255% and -14.2% removal efficiency for BOD, TSS and total phosphorus respectively. Maturation pond 1 showed 55%, -427%, and 87.5% removal efficiency for BOD, TSS and Total phosphorus; whereas maturation pond 2 showed 6.4%, -10.6% and -26.7% removal efficiency for BOD, TSS and Total phosphorus respectively. Temperature was measured at sampling point, and temperatures ranged from 20 to 28 ºC. Removal efficiencies of these ponds were thought to be affected by inadequate maintenance and introduction of detergents into the ponds by people living around the treatment plant. The plant thus needs better management and an upgrading, to ensure the protection of the environment and public health..

Keywords: Wastewater, Wastewater stabilization ponds, Efficiency, Upgrading.

1. Introduction

Lesotho is a mountain kingdom in the Sub-Saharan Africa, surrounded by its only neighbouring country, South Africa. It has a surface area of just over 30,000km², with a population of about 2 million inhabitants. Maseru is the capital city, directly on the Lesotho-South Africa border. The population of Maseru is about 227, 880, with a size of approximately 138km².

Wastewater (as blackwater) emanating from parts of Maseru is treated at the Ratjomose wastewater treatment plant. The main reasons for the treatment are to prevent environmental pollution of soil, surface water and groundwater, to protect the receiving water (the fluvial environment of the Caledon River in this case), by enabling acceptable discharge. Other reasons are to prevent eutrophication, and to protect public health, together with ensuring environmental aesthetics.

The Ratjomose wastewater treatment plant (RWTP):

At the Ratjomose wastewater treatment plant, the Water and Sewerage Company (WASCO) is the service provider. The plant is the largest sewage treatment facility in Lesotho, making use of conventional treatment technologies, waste stabilization ponds being quite prominent. It is found South West of Maseru on the banks of the Mohokare (Caledon) River.

Sewage sources are industries, hospitals and homes in and around Maseru. The sewage is brought by a sewerage network. The contents of the sewage include plastics, twigs, human wastes, etc (blackwater). The sewage flows through two main sewers of 1.5m diameter, handling up to 20 m^3/day. Figure 1 shows the treatment flow scheme.

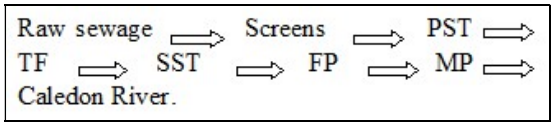

Figure 1. Treatment flow scheme at the Ratjomose wastewater treatment plant

The main stages of the treatment scheme are depicted in Plates (A-E) in figure 2. The plant serves a catchment area of about 20 km^2. The topography of Maseru has enabled installation of eleven pumping

A

B

C

D

E

Figure 2. Plates of the treatment scheme: A-Screens; B- PST; C- TF; D- SST; E- Pond system.

stations to assist in transporting sewage to the treatment plant under gravity. The population served is estimated to be over 12 000.

The treatment plant treats the blackwater through the following four stages: preliminary treatment (with the screens), primary treatment (through sedimentation), secondary treatment by four trickling filters, two facultative and four maturation ponds. Due to the use of the trickling filters, the pond system has no anaerobic ponds. The trickling filters remove about 60% of Biochemical Oxygen Demand (BOD) and the effluent goes straight into the first facultative pond. Tertiary treatment is with the maturation or aerobic ponds.

Table 1 shows the pond characteristics. F1 indicates the first facultative pond, F2 the second facultative pond, M1 the first maturation pond and M6 the fourth maturation pond (6^{th} pond).

The principal objectives of the research were to:

- Determine the levels to which waste stabilization ponds (WSPs) at Ratjomose sewage treatment plant remove Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and Total Phosphorus (P), to determine their treatment efficiencies.
- Determine factors that affect the efficiency & effectiveness of the WSPs.

2. Materials and Methods

Grab samples of wastewater from the influents and effluents of facultative ponds (F1 and F2) and maturation ponds (M1 and M6), were analyzed twice according to standard analytical procedures for water analysis [1]. Temperature (T) was taken at sampling point with a thermometer. the samples were transported in an ice box to the laboratory and stored at 3°C. Phosphorus (P) samples were preserved with conc. sulphuric acid. BOD was analysed using the Winkler Azide Titrimetric method. Totao suspended solids

Table 1. Pond characteristics with sampling points (F1, F2, M1, M6)

STABILIZATION POND	LENGTH (m)	WIDTH (m)	DEPTH (m)
F1	650	166	1.8
F2	333	171	1.8
M1	228	68	1.5
M6	171	114	1.5

(TSS) was determined by gravimetry, following heating at 105°C overnight. P was determined by Digestion and Ascorbic Acid Spectrophotometry.
Treatment Efficiency was measured as:

(output/input)×100%, where:

Output= influent concentration – effluent concentration and Input= influent concentration

3. Results and Discussion

Table 2 shows the removal efficiencies for the 3 parameters- BOD, TSS and P for trial 1. Results for trial 2 were similar and are not shown.
Removals for all 3 parameters were good for F1 (entry into the pond system). At other levels of the pond system there was hardly any removal, pointing to low maintenance as one reason. But the presence of the parameters in influents was also low.
The ponds need to be disludged, as there are surely dead spaces (sludge occupied), causing reduction in hydraulic retention time [2]. This was confirmed by a worker at the plant, who talked of no pond disludging since he started working there. However, such results are not far from similar systems in other developing countries. See, for example, [3].
The results showed good removal efficiency of BOD, TSS and total phosphorus at F1 and poor in the other WSP stages, both in trials 1 and 2. Temperature was measured at sampling point, and the temperatures ranged from 20 to 28°C. The removal efficiencies of these ponds were affected by inadequate maintenance and introduction of detergents into the ponds by people living around the treatment plant. Indeed, generally,

Table 2. Removal efficiencies

Pond's Name	Parameter	Influent (mg/l)	Effluent (mg/l)	Removal Efficiency (%)
F1	BOD_5	1.572	0.943	40
	TSS	148.4	10	93.3
	Total phosphorus	18.8	2.8	85.1
F2	BOD_5	0.943	3.145	-233.5
	TSS	10.0	35.5	-255
	Total phosphorus	2.8	3.2	-14.2
M1	BOD_5	3.145	1.415	55
	TSS	35.5	187.1	-427
	Total phosphorus	3.2	0.4	87.5
M6	BOD_5	2.67	2.5	6.4
	TSS	75.13	83.12	-10.6
	Total phosphorus	6.0	7.6	-26.7

stabilization ponds are said to be of low cost, low maintenance and highly efficient in removal of nutrients, biochemical oxygen demand (BOD) and pathogens, but may fail, due to lack of technical knowledge, and failure to consider all relevant local factors at the pre- design stage. So, the ponds have been well designed [4], but their operation and maintenance are not optimal.

4. Conclusion and recommendations

The facultative and maturation ponds are found to be well designed. However, from poor operation and low maintenance, results are not good, especially for sections after F1.
Rock filters may be installed to further polish the maturation pond effluent. Retrofitting of baffles into the ponds may also help. Again, the public should be kept away, as people interfere with the pond functions, e.g. by introducing detergents (P) that lead to eutrophication.

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National Action Plan for Reducing Maternal Mortality in Lesotho

Amelia Mashea[1,*], Motsoanku 'Mefane[2], 'Mantsane Tsoloane-Bolepo[3], Nkeme Sehalahala[4]

[1] *National University of Lesotho, Roma, 180, Lesotho.*
[2,4] *Ministry of Health, Family Health Division, Maseru, Lesotho.*
[3] *World Health Organisation, WHO, Country Office, Lesotho.*

[*]**Corresponding author:** Phone (+266) 5844 0688; E-mail: masheam@yahoo.com.

Abstract: Lesotho has been suffering a negative trends of escalating maternal mortality ratio since 2004.Currently the country is at 1024/100 000 live births as per 2014 LDHS [1]. The objectives of this study was to identify the possible gaps that could have contributed to the increasing mortalities and develop strategies that will reduce this problem. The Verbal Autopsy Tool and Maternal Notification Form were used to collect data of all maternal deaths occurring at community and health facilities respectively, covering the years 2010 to 2016. All facility and community based maternal deaths reports were done by the trained MDR and data captured was analysed using MaMMAS software. The causes of maternal deaths were classified using the ICD-10 coding system. For practical implementation of data analysis the office of the secretariat personale was trained on the use of the software (MaMMAS). The first Maternal death report was released and shared with stakeholders in 2010. The verbal autopsy tool designed was communicated to all primary health facilities to report the maternal deaths occurring at community level. There is great improvement in the reporting of cases from the movement of Lesotho facilities, Christian Health Association of Lesotho and private facilities. However, following the recommendations made, there is decline in reported maternal deaths since 2010.

Keywords: Maternal Mortality, Lesotho Confidential committee of enquiry into maternal deaths (LCCEMD).

1. Introduction

Lesotho is a small mountainous country landlocked by the Republic of South Africa; Figure 1. It has been battling with high maternal mortality throughout the years. In response to this burden, the Ministry of Health through Family Health Division conducted maternal death audits countrywide in August 2017. It was aimed at assessing all facility and community-based maternal deaths that occurred from 2011-2016 with the objective of identifying institutional challenges, gaps and strengths towards prevention of maternal mortality; providing feedback and response on assessed cases; outlining recommendations with timelines and responsible persons.

2. Material and Methods

A group of maternal death assessors from all the districts of Lesotho took part in the assessment of maternal deaths covering the years 2010 to 2016. This exercise was done by visiting the health facilities.
facilities, mainly the hospitals, both Christian Health Association of Lesotho(CHAL) and Public Hospitals. A total of 296 maternal deaths were assessed. Some reported deaths were spoiled due to incomplete information or missing documents. The data was

Figure 1. Map of Lesotho.

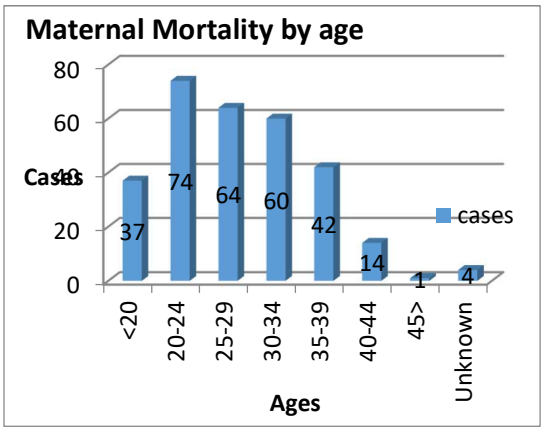

Figure 2. Distribution of maternal deaths by age(n) 2010-2016.

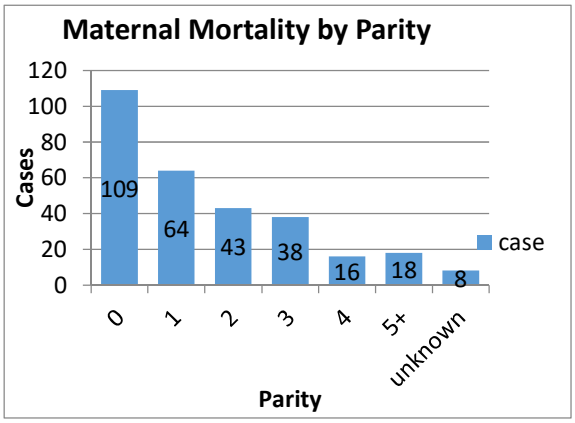

Figure 3. Distribution of maternal deaths by parity (n) 2010-2016.

collected and analysed using MaMMAS software. The causes of deaths were done according to the International Classification of Disease Coding (ICD-10).Surrounding issues that lead to the deaths of women were discussed with the staff in each affected health facility respectively. The composition of staff that was addressed during the discussion included representation from Birth Attendants in the form of Doctors, Midwives, Administrative staff, Pharmacy staff, the Laboratory staff and representatives from the District Health Management Teams (DHMT) on behalf of the Community. The discussions were not aimed at punishing anybody but rather establish possible causes and making workable recommendations together. Challenges faced by the staff were raised and addressed by all parties.

3. Results and Discussion

The audits yielded the following results based on the 296 assessed cases covering the years 2010-2016 (Table 1). The table below shows that majority of maternal deaths occurring in Lesotho are attributed to obstetric haemorrhage and Hypertensive disorder with the highest percentages, 31.4%, 5 and 28%.respectively (Table 1). The results also revealed that most mothers who are dying during the process of pregnancy, child birth and peuperium are between the ages of 20 and 39 years (Figure 2). Most of these mothers losing their lives during the process of childbirth are having their babies for the first time or are having their second baby (Figure 3).

Table 1. Causes of maternal deaths-ICD-10 Coding

Causes	2010	2011	2012	2013	2014	2015	2016	Total	%
Coincidental	3	2	1	2	1	1	0	10	3.4
Medical	4	2	6	4	5	1	1	23	8.6
Non pregnancy related	4	5	6	5	2	0	0	22	7.4
Pregnancy related	4	3	4	4	3	3	5	22	7.4
Miscarriages	0	1	3	2	5	2	1	14	4.7
Obstetric haemorrhage	14	16	20	13	9	11	10	93	31.4
Hypertension	12	18	19	5	10	5	13	82	28
Anaesthesia	4	1	3	1	2	2	1	14	5
Embolism	0	0	1	2	0	1	0	4	1.4
Respiratory factors	0	1	1	0	1	0	0	3	1
Unknown	0	0	2	2	0	1	0	5	1.7
Total	45	49	66	40	38	27	31	296	100

4. Conclusions

Based on the above results, it is obvious that maternal deaths can be prevented since the conditions that seem to be the major killers of women are preventable if correct measures are taken throughout the process of pregnancy and child birth. Health care providers should show responsibility and ensure that unnecessary delays while executing maternity services are avoided. This will not only reduce maternal mortalities but will address the United Nations Sustainable Development Goal 3, target 1&2 [3].

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Bioenergy for Africa - The Quest for Energy Independence and Food Security

S.B. Mekbib[1,*], M.J. George[2], M.V. Marake[3]

[1] *Department of Biology and Biotechnology,*
[2] *Department of Chemistry and Chemical Technology,*
[3] *Department of Soil Science,*
National University of Lesotho, P. O. Roma 180, Lesotho.

[*]**Corresponding author:** Phone: (+266) 63242329; E-mail: sbmekbib7@gmail.com / sb.mekbib@nul.ls

Abstract: Energy is vital to sustain life activities and stability of the environment. However, dependence on fossil fuel besides creating crisis to the environment, it hugely affects human values. The deepening crisis in energy and food security in many Least Developing Countries of Africa is worsening due to poor economic conditions, crop and livestock disease epidemics, and the high incidence and impacts of HIV and other associated tropical diseases. A recent estimate indicated that more than 700 million people in the region are vulnerable to food insecurity and energy crisis. Renewable energy sources are viable options to halt the damaging effects of fossil fuel to the environment and society. Africa has great potential in biomass resources that can be used as biofuel and biofertilizer for sustainable development in this bio-energy arena. Emergency responses that focused on food aid to reduce sufferings do not provide long-term development solutions to Africa. Underutilized or poorly administered biomass resources of Africa has to be utilized and it is a requirement to introduced advanced adoptable technologies to nations and device a workable policy to support such initiatives towards implementation of the clean energy practices for household and community purposes. Besides energy security, this would leverage a wide range of income generation to the family and communities to support their livelihood. The role of biomass technologies with other renewable energy practices has not yet been fully exploited. The Africa-EU partnership is highly mandatory to mobilize resources to create cleaner, much affordable and sustainable renewable energy sources for energy and food security in Africa.

Keywords: Renewable energy, Bioenergy, DRE system, SSPS system, Low carbon energy, Waste management,; Biogenic electricity and economy.

1. Introduction

In Africa, an energy demand is concomitantly growing with an increasing of population. At present, more than three quarters of the total energy demand is met by biomass fuels directly from shrubs, firewood and animal dung. The majority of households (700 million people) in sub-Saharan Africa are vulnerable to food insecurity and energy crisis and are rely solely on traditional biomass for cooking and heating with this number projected to hit about 900 million people in 2020 if this trends continue [1]. Efforts to bring modern energy access to all – electricity and clean fuels – are far outpaced by population growth. Traditional biomass use has multiple negative impacts, most notably on respiratory health: 600,000 lives are lost each year in sub-Saharan Africa due to exposure to biomass smoke. The economic costs of high reliance of biomass for cooking are also substantial, about US$36.9 billion per year, or 2.8% of GDP, including US$29.6 billion from productive time lost gathering fuel for cooking [1]. The impacts are particularly severe for women and girls, who are typically responsible for these chores. There is a growing body of knowledge and experience about how best to achieve a shift to cleaner and safer use of biomass fuels for cooking, heating and electricity.

In Lesotho, the residential energy demand coverage reaches 88% to urban and 95% in rural areas [2]. Direct utilization of biomass such as wood and animal droppings are the most typical examples of energy recycling system with wood accounting for 70%, animal dung 25% and the remaining 5% taken by other crop residues and any other combustible materials with coal [3]. However, the cutting of shrubs and woods for fuel consumption, besides increasing the impact of greenhouse gas effect and desertification, it will eliminate diversity of indigenous and exotic tree species.

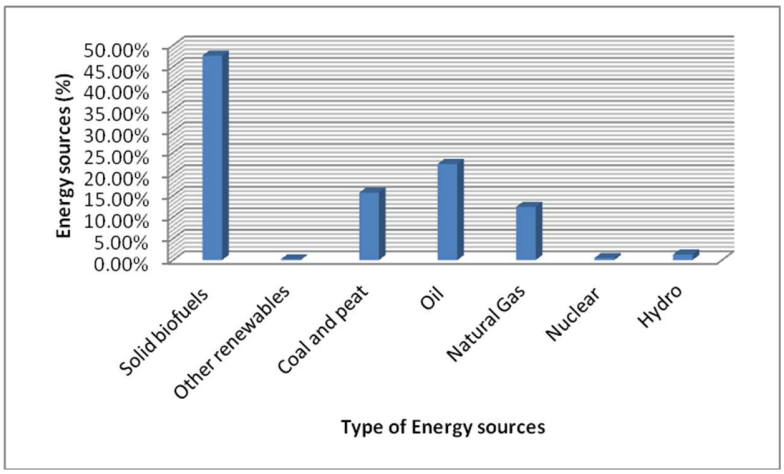

Figure 1. Energy sources type and consumption in Africa [8].

While securing energy requirements, establishment of environmentally compatible technologies that support the livelihood of the poor by sustainable use of natural resources is mandatory. Some practices involving the production of biogas from night soil and cattle manure has seen to be implemented by local NGOs

The role of biomass technologies with other renewable energy practices has not yet been fully exploited for sustainable production of energy and food security to the community. It is only at the inception and introductory level and has not reached scale levels with benefits to household livelihoods, environment and economies. There is an urgent need to ramp up these initiatives tailoring to the specific conditions in each country.

A variety of raw materials which include agricultural wastes (plant residue, animal faeces and fish farm waste), municipal wastes, market garbage, and waste water from food and fermentation industries are used for production of biofuels either in solid or liquid forms. The sludge after this can also be used as biofertilizer to cultivate crops for family food security. The cultivation /production of grasses such as Napier, Carajas and Vetiver varieties besides being used as a feedstock for the production of biofuel, it can also benefit the communities as an animal fed and means of soil conservation. However, the role of biomass technologies with other renewable energy practices has not yet been fully exploited in Africa. According to the World Bank [4], sub-Saharan Africa will require more than $30 billion in investment to achieve universal electricity by 2030. Rural sub-Saharan Africa will require the vast amount of the funds, with more than 85% of those living in rural areas lacking access to reliable electricity [4]. Therefore, stakeholder partnership such as Africa-EU partnership is highly mandatory to mobilize resources to create cleaner, much affordable and sustainable renewable energy sources for energy and food security in Africa.

This review assesses and evaluates the biomass resources of Africa and their utilization with technological approaches for family/community energy and food security.

2. Africa's energy resources access and potential

Sub-Saharan Africa today is in the midst of a dramatic urban transition that will persist well into the 21st century. Between 2010 and 2035, the urban population is expected to more than double from approximately 298 million to 697 million. By mid-century, it is estimated that over 1 billion people will live in urban areas. While urbanization has the potential to act as an engine of economic growth and human development it also brings enormous challenges in improved waste management services. In low-income countries, in particular, rapid urban growth and community development put extraordinary pressure on limited urban resources for the provision of essential basic services such as education, health and energy provision to the public. Indeed, there is perhaps no area where the capacity to manage urban waste is more urgent and more challenging than in informal settlements.

Compared to the rest of the world, there is a general shortage of energy related information in Africa on potential of energy resources, actual installed systems and current energy uses. It is indeed difficult to compare the potential for the different energy options due to the scattered validated information [5]. This lack of information is even more apparent for renewable energies [5]. Nevertheless, available data sources are in agreement in describing a difficult situation as far as access to energy is concerned.

However, the continent possesses abundant renewable resources that could spur continued economic growth, accelerate social development and help the transition to a sustainable energy system that can provide universal energy access. The community and city council solid and liquid waste sources can be thought of high energy potential if properly managed to maintain the health of the environment and economy. In Africa, the Waste to Energy recovery is currently under way involving energy recovery technologies namely combustion of waste and anaerobic digestion in some countries, which is the best practice for the environment, health and economy. The Cows to Kilowatts project in Ibadan, where the plant generates the equivalent of 0.5MW of electricity daily and became the first plant in the world to simultaneously treat abattoir waste and provide domestic energy and organic fertilizer; and the eThekwini Landfill Gas to Electricity project in Durban, which generates 7.5MW of electricity from 2 landfill sites [(6], the BMW Company to produce 25-30% of its energy demand from animal dung and other organic wastes, South Africa [7]. The waste to biogas projects in prisons in Kissi and Homa Bay in Kenya, Bamako in Mali, and a tourist location on the beaches of Dakar for instance are some of the practices in Africa [(6]. In addition to the above, UN-Habitat is involved in the production of briquettes from the organic waste fraction of wastes as a substitute for wood charcoal, while providing a source of income for small businesses. Multifunctional Clean Energy Centres (MCECs) have been established in informal settlements in select African cities [6]. Figure 1 shows the degree of use of different energy sources in Africa.

As can be seen, from figure 1 above, the use of solid biofuels far exceeds all other sources at just over 45% with oil a fossil fuel coming second at about 20%. An emerging concern for carbon emissions fossil fuels and sustainable development has created an opportunity for renewable energy using solid and liquid community and municipal wastes on the continent.

Renewable energy sources available for Africa:

wind, hydro- and biomass) that could spur continued economic growth, accelerate social development and help the transition to a sustainable energy system that can provide universal energy access.

In the world today, renewables accounted for 6.7% of global power generation. China (+20.9%) and Germany (+23.5%) recorded the largest increments in renewables in power generation. Globally, wind energy (+17.4%) remains the largest source of renewable electricity (52.2% of renewable generation), with Germany (+53.4%) recording the largest growth increment [4]. Solar power generation grew by 32.6%, with China (+69.7%), the US (+41.8%) and Japan (+58.6%) accounting for the largest increases. China overtook Germany and the US to become the world's top generator of solar energy. Global biofuels production grew by just 0.9%, well below the 10-year average of 14.3%: Brazil (+6.8%) and the US (+2.9%) accounted for essentially all of the net increase, partly offset by large declines in Indonesia (-46.9%) and Argentina (-23.9%) [4].

The total primary energy demand (TPED) for Africa is predominantly determined by biomass demand (figure 1). Sub-Saharan Africa estimated to provide more than 170 Giga watts (GW) of additional power-generation capacity, which is more than double the region's current installations through 3,200 "low-carbon" energy projects, such as combined heat-and-power, biofuels production, mass transportation, and energy efficiency [4]. Just a 0.3% of the sunlight that shines on the Sahara and Middle East deserts could supply all of Europe's energy needs [9]. The renewable energy projects potential in Africa as estimated by World Bank can provide about 170 GW worth of low-carbon energy that may require a total capital of $157 billion, but would avoid approximately 740 million tons of carbon dioxide emissions each year [4]. The support for Africa Climate Business Plan (ACBP) will increase climate resilience and develop an energy efficient and sustainable source of energy predominantly composed of biomass and waste.

Biomass feedstock:

Accessing potent feedstock has always been one of the main challenges of developing biogenic power plants in Africa. Several biomass sources can be used as feedstock for the production of flammable biogases. The following are feedstock sources for the anaerobic digester:

i. Organic crop wastes: farm leftovers and postharvest plant litter and plant debris are used as a feedstock for the bioenergy plant.
ii. Night soil: sewage water from municipal city.
iii. Animal feaces (manure) (cattle, pig and chicken…) from agricultural farms.
iv. Cultivated grasses: Vetiver, Napier and Carajass.
v. Water hyacinth, which is an invasive plant taking over Lake Naivasha, in Kenya and lake Tana, Ethiopia for instance, can be used for power generation being used as a feed stock.

Benefits of biomass from power generating plants:

Biomass power plants will not only help provide energy to those populations without access, but also will reduce the need to collect wood and burn/buy charcoal. Bioenergy products range from a simple log, to a highly refined transport fuel. Biomass can also provide thermal, electrical and mechanical energy services. Different products suit different situations and

objectives. The choice of product may be affected by the quantity and cost of biomass types available; location of fuels and users; type and value of energy services required; or other co-products [10]. Highest overall efficiency is often a result of capturing more than one service e.g. in combined heat and power plants. This translates to a reduction of energy expenditure if power from the plants is cheaper. A 10% increase in biogas production could cut down deforestation by an equivalent of 9-35% [10]. Biogas power generation can also help cut down carbon emissions by displacing fossil fuel-generated power from grids. From environment and health point of view, it helps in reducing spread of pathogens and disease incidences. For agricultural purposes, the residue from the power plants is bioslurry and can provide nutrients to improve crop production being serving as organic fertilizers and soil organic modifer that has no side effects to life and environment unlike chemical fertilizers.

Investment attraction:

In order to attract large investments in renewable energy technologies, a thorough planning phase is necessary to estimate the energy share that can be supplied by renewable energy sources; compare energy costs with that of conventional solutions and to identify the most effective technologies that are adaptable to local conditions [8]. This enables countries to develop adequate policy frameworks and financing instruments, to nurture human capacity and to create the necessary infrastructure to fulfill their sustainable energy aspirations. For countries to properly analyze and plan the use of renewable energy, they need accurate and documented estimates of their renewable energy potential, as well as to identify the most suitable locations for investment and deployment in renewable energy technologies. The accuracy of this information correlates directly with the risk taken in the decision-making process. Accurate data strengthens each country's national strategy to deploy renewable energy technologies.

Regional bodies in Africa have started to recognize the opportunity and challenges to establish the Center for Renewable Energy and Energy Efficiency (ECREEE), forming strategic development pacts with several international organizations that include the European Union (EU), United Nations Development Program (UNDP) and the United Nations Food and Agricultural Organization (FAO) [11]. The renewable energy initiative that is currently running at some parts of Africa, for instance, in Lesotho, Botswana through Africa-EU partnership with governoment, higher learning institutions and many other stakeholders is one of a kind that has to be continued in other parts of Africa.

Distributed Renewable energy systems:

The impending deregulated environment facing the electric utilities in the twenty first century is both a challenge and an opportunity for a variety of technologies and operating scenarios. Distributed renewable energy systems generate clean, renewable electricity on site, where that energy will be used. The term distributed generation distinguishes these systems from the large, centralized power plants that provide the vast majority of the nation's power. Distributed renewable energy systems can take many forms, including geothermal systems, micro-hydroelectric systems, solar panels, wind turbines, and biomass [12], [13]. There are many programs and policies that can either help or hinder the adoption and integration of distributed energy systems. Municipal solid waste (MSW) and natural waste, such as sewage sludge, food waste and animal manure will decompose and discharge methane-containing gas that can be collected and used as fuel in gas turbines or micro turbines to produce electricity as a distributed energy resource. A distributed energy resource is not limited to the generation of electricity but may also include a device to store distributed energy (DE) [14]. Distributed energy storage systems (DESS) applications include several types of battery, pumped hydro, compressed air, and thermal energy storage [15]. Access to energy storage for commercial applications is easily accessible through programs such as Energy Storage as a Service (ESaaS) [15].

Sustainable service and product system:

Service is an action or an activity which can be offered by a party to another party, which is basically intangible and can not affect any ownership. This conventional services marketing definition only draws little attention to the element of sustainability. However, starting in the 1980s and especially growing since the 1992 Rio Earth Summit stakeholders and customers likewise increasingly considered the environmental and social consequences of the products they bought [16]. The consumer green movement imposed tremendous pressure on both businesses and governments to reduce the environmental impact of their production and consumption, leading to an increasing demand for developing concepts for a more sustainable future. These early ideas later on developed from cleaner and greener improvements to processes and products and new products and services-mixes [17]. In the current smart business concept, companies have started reviewing their organizational performance by adding environmental quality and social benefits to economic prosperity as part of their business evaluation process and adopting green services and products to reach ever-increasing environmentally aware consumers [18]. To this effect,

the concept of sustainable product-service systems has emerged recently, and is distinct from the ideas of cleaner production, eco-design and design for the environment [16]. The concept goes beyond the environmental optimization of products and processes and requires radical and creative thinking to reduce environmental impacts by a factor of between 4 and 20 times while maintaining an acceptable quality of service. Sustainable product-services consider alternative socio-technical systems that can provide the essential end-use function, such as warmth or mobility, that an existing product offers. Four types are outlined—result services; shared utilization services; product-life extension services; and demand side management. Sustainable product-service systems attempt to create designs that are sustainable in terms of environmental burden and resource use, whilst developing product concepts as parts of sustainable whole systems that provide a service or function to meet essential needs [16].

Policy issues and legislation:

In Africa, policies crafted on the use of "nature's capital" (air, water, and sun) has to be diverted to the use of "nature's income" (waste (solid/liquid), and biomass…)) for the production of bioenergy-electricity. For instance, a proposed mission statement for Lesotho's renewable energy policy is framed to manage and develop water and land resources for diversified economically sound and sustainable irrigation and drainage systems. As land is owned by the people in Lesotho, it is allocated by and through the traditional structure of chieftainship. Until very recently, when new forms of land holding were introduced, there was little legal (as opposed to customary) security for the tenants [19]. For irrigation and renewable energy projects this has had major consequences, as the high fixed costs of providing the systems are only justifiable when the benefits can be shared between many recipients. The existing framework of land tenure is not likely to change rapidly and thus any effective irrigation and renewable energy scheme would in the short to medium term have to work within it. New policy documents has to be framed on the bases of bioenergy projects development for better management [20].

Challenges:

New bioenergy sources including biohydrogen, microbial fuel cells, bioethanol, and biodiesel production are ideal options in the future for fulfilling ever-increasing energy demands. However, the technology gap between research and industrial application still exists. The field of bioenergy is interdisciplinary, requiring the knowledge of biologists, chemists, physicists, and engineers. Exploring the current trends and future prospects for biofuels will be valuable for identifying new options to circumvent problems that exist in bioenergy applications.

3. Conclusion and recommendation

Without access to energy, Africa's growth will be stifled and, investing in energy solutions for the continent is an absolute necessity. Renewable Energy in Africa is a huge opportunity to allow for a better standard of living for a large part of current and future population in Africa. However, it should be pointed out that much of the knowledge has be transferred swiftly to research and technology partners in Africa in collaboration and co-operation with the wide range of existing research and university infrastructure. It is only if such activities can be deployed in research, prototyping and demonstration that would accelerate the uptake of renewable energy in Africa. Strategies for fostering international collaboration in using its biomass resources are required to tap resource to maximize its development while minimizing its impact to the environment. In summary, many of these initiatives are providing benefits in terms of low-carbon energy generation, reuse of waste, effective land use and reduced deforestation if funding organizations, government and other implementing agents are working hand in hand together.

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Lesotho Medicinal Plants of the Acteraceae Family: A Review of the Ethnobotany, Chemistry and Conservation Status

Mohale B. Mabaleha[1,2,*], Susan L. Bonnet[2], Anke Wilhelm[2]

[1] *Department of Chemistry & chemical technology, National University of Lesotho, Roma 180, Lesotho.*
[2] *Department of Chemistry, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa.*

[*]**Corresponding author:** Phone: +27 634 310 120; E-mail: mmabaleha@yahoo.com

Abstract: Plants have and continue to play a pivotal role in the wellbeing of humankind, either in the form of food, fuel, medicine or shelter**.** Several plant species from a diverse range of families are used in Lesotho for medicinal purposes. For example, *Dicoma anomala* (hloenya) is used to treat breast cancer while *Aster bakerianus* (phoa) is effective against sexually transmitted infections (STIs), particularly syphilis. While ethnobotanical information about most of Lesotho medicinal plants is well documented, the scientific validation and conservation status of these plants remain subjects of concern. In spite of their important role in primary healthcare and as sources of livelihood, medicinal plants in Lesotho are faced with ever-increasing threats. Exponential growth in trade of some of these plants, coupled with socio-economic factors lead to unsustainable and uncontrolled harvesting [2, 3]. Climate change, overgrazing and veld fires also add to the problem. The family, Asteraceae provides an arguably significant number of Lesotho plant species used in traditional herbal medicine. This study provides an in depth account of the ethnobotany, chemistry and conservation status of selected medicinal plant species of the family, Asteraceae that are commonly used in Lesotho traditional medicine and cited most in the literature. According to the literature, the ethnobotanical information for the sampled species is satisfactorily preserved. The reported medicinal uses cover a wide range of ailments from circulatory, gastrointestinal, respiratory, reproductive, pain relief, digestive and other non-classified sicknesses. Terpenoids (especially sesquiterpene lactones), flavonoids and phloroglucinols are some of the characteristic metabolites of this family. The observed biological activities are in close agreement with the reported metabolites. This study concludes that the ethnobotanical knowledge of Lesotho medicinal plants of the family, Asteraceae is adequately covered. However, gaps still exist in the isolation of active ingredients (drugs) for pharmaceutical purposes and elucidation of their mechanisms of action. The issue of conservation of Lesotho flora remains a challenge even today.

Keywords: Review, Lesotho medicinal plants, Asteraceae, Conservation status.

1. Introduction

The flora of Lesotho comprises about 3,000 species, belonging to 800 genera and 200 families [4]. Economically, it provides food, energy, shelter, handicrafts, clean environment and medicine to Basotho. It is noteworthy that rural population of Lesotho depends heavily on biological resources, especially plants, for their livelihoods [5]. The rate of harvesting this natural resource, without replenishing, however, is exceedingly high. This puts too much pressure on this already dwindling resource. The problem is exacerbated by factors such as climate change, wild fires, unsustainable use and destruction of habitats. Asteraceae (Compositae) is one of the best represented families in the flora of Lesotho. Commonly known as the sunflower family, daisies (members of the Asteraceae family) exist as herbs, some as shrubs, and rarely trees. Globally, it is the largest family of dicotyledons, comprising about 2000 genera, and 32, 913 species [6]. The family has a cosmopolitan distribution although it is most abundant in tropical and subtropical regions, as well as the lower temperate latitudes [7]. Daisies can be distinguished from other plants by their characteristic inflorescent flowers [8]. They are best known as producers of sesquiterpene lactones of various forms. The absence of irridoids in their essential oils gives them a unique property compared to essential oils from other plants [9]. Members of this family find use in food, cola, insecticide and cigarette industry (Tagetes spp), as well traditional medicine (Artemisia). Helianthus annuus (domestic sunflower), is best known as the source of cooking oil. Several genera are of horticultural importance (Chrysanthemum, Calendula) [10].

Research suggests that the family Asteraceae, provides a significant number of Lesotho plant species used in traditional medicine. Moteete has conducted several ethonobotanical researches on the flora of Lesotho. Most of her research work was premised on the literature from Phillips, Watt & Breyer-Brandwijk, Hutchings and Guillamord. Further studies, on different aspects, have been done by Maliehe, Letsela, Shale, Mugomeri, Seleteng-Kose, Motjotji, Van Wyk, Asita etc. While ethnobotanical information about several members of this family is well documented, as chemical studies, including scientific validation of the myriad ethnomedicinal uses are underestimated. The conservation status of not only members of this family, but the flora of Lesotho as a whole remains unaddressed. Furthermore, reviews that compare and contrast among members of this family are unknown**.** This review, therefore, provides an in depth account of the ethnobotany, chemistry and conservation status of selected members of the Asteraceae family that dominate Lesotho traditional herbal remedies and are cited most in the literature.

2. Materials and Methods

A comprehensive literature search from online databases (google, google scholar etc), in published and unpublished articles (journal articles, dissertations, theses etc.) and books provided the main sources of information used in this paper.

3. Results and Discussion

Traditional and medicinal uses of the family:

One of the greatest applications of members of the Asteraceae family in Lesotho is in traditional medicine. Few other applications include sources of energy (firewood) for cooking purposes (*Aster*, *Athanasia*, *Eriocephalus*, *Chrysocoma* spp), and as wild vegetables (*Gerbera*, *Hypochaeris*, *Senecio* and *Sonchus* spp) [**5**]. Nearly all the plants in this review are used to treat coughs, fevers and colds; influenza and gastrointestinal disorders. Diabetes, one of the non-communicable diseases in Lesotho is best treated using decoction from the likes of *Artemisia afra* and *Dicoma anomala*. Other ailments treated are related to skin problems, reproductive, circulatory, cardiovascular, degenerative, CNS-related disorders and general aches. Detailed account is given in Appendix 1.

Phytochemistry:

Medicinal applications of plants are largely determined by the presence of active ingredients (active compounds) present in those plants. These compounds may exert medicinal properties on their own i.e in isolation. Sometimes a group of compounds may work together (synergy) to exert certain attributes of medicinal value. A wide range of metabolites have been reported from Asteraceae. The commonest include terpenoids, flavonoids and their derivatives, and iso/phloroglucinols. Sesquiterpene lactones are the largest class of terpenoids that characterize Asteraceae. They are largely responsible for the observed biological activities of most members of this family. It has been argued that flavonoids play a vital in the prevention of neurological and cardiovascular diseases [11-12]. Other metabolites of medicinal value include saponins, phenyl propanoids, alkaloids, fumaric and caffeic acids. The unique characteristic of most members of this family is the absence of irridoids in the essential oils isolated. The genera *Helichrysum*, *Artemisia* and *Eriocephalus* are reputed for their rich essential oils.

Examples of typical biological activities:

Antioxidant activity: Among the top ten causes of death in Lesotho are degenerative diseases such as heart failure, anaemia, *diabetes mellitus* and stroke, which are generally linked to oxidative stress. The therapeutic benefit of medicinal plants in the treatment of degenerative diseases is attributed to their antioxidant properties [**13**]. Bioactive phenols (especially bioflavonoids) are very interesting as antioxidants because of their natural origin and the ability to act as efficient free radical scavengers [**11-12**]. Extracts from plants such as *A. afra*, *B. setifera*, *E. panctulatus* and *H. odoratissimum* have been studied and found to possess antioxidant properties on DPPH and ABTS cations. This activity is attributed to the flavonoids and other polyphenolic compounds that have been isolated from them. The volatile oil of *Artemisia afra* has shown antioxidant and antimicrobial activities [14]. Evaluation of the antioxidant and free radical scavenging properties of *Berkheya setifera* showed that the plant scavenged DPPH radicals and hydrogen peroxide. The plant further reduced Fe^{3+} to Fe^{2+} and was found to contain phenolics. A fair degree of correlation between the amount of total phenolic substances and the activity was established, where extracts with high content of phenolics gave higher activity [13].

Anti-inflammatory activity: All, but three, of the selected members of the Asteraceae have been studied and showed anti-inflammatory activity. These include *S. pinnata*, *H. scarposa*, *S. asperulus*, *B. setifera*, *D. anomala* and *Helichrysum* species. It has been reported that sesquiterpene lactones exhibit anti-inflammatory and immunomodulatory actions, properties that can be beneficial in tumor treatment [15]. The anti-inflammatory activity of most members of the

Asteraceae can therefore be attributed to the presence of sesquiterpene lactones.

Antimicrobial (antibacterial, antifungal, anti-mycobacterial, antiviral) activity: Extracts from *A. afra, B. setifera, G. woodii, E. punctulatus, S. pinnata, O. natalensis, Senecio* and *Helichrysum* species all show antimicrobial properties of varying degrees. *Senecio asperulus* has traditionally been used in the treatment of herpes and syphilis. A wide application of most members of this family in the treatment of sores and wounds is testimony to their antimicrobial activities. The antimicrobial activity of the volatile oil of *Artemisia afra* has been highlighted in the previous sections. Antiseptic leaf decoctions of *Schkuhria pinnata* are used in the treatment of wounds and fevers.

Antidiabetic activity: Diabetes mellitus has been declared the commonest endocrine disorder. Globally, an estimated 422 million adults were living with diabetes in 2014, compared to 108 million in 1980. Diabetes caused 1.5 million deaths in 2012 [**16**]. The root causes of diabetes mellitus are largely related to diet and people's lifestyles. In this changing world that is greatly influenced by western lifestyles, diabetes cases are alarmingly increasing. Consequently, plants play a central role in the search for effective remedial measures. Extracts of most plants under review have shown antidiabetic properties. This property has led to the extensive use of *D. anomala*, *A. afra*, *E. panctulatus*, *H. scaposa* and *S. pinnata* extracts by diabetic patients in Lesotho. *Artemisia afra* has been used to keep urine free from sugar in the case of diabetes mellitus [**17**]. Furthermore tea infusions of *S. pinnata* are used by traditional healers and herbalists in the Ga-Rankuwa area, Gauteng, to treat diabetes [18].

Antitumor activity: Research has proven that flavonoids and some sesquiterpene lactones can synergistically act against malaria and cancer [**19**]. In vitro anticancer screening of selected South African medicinal plants revealed that eucannabinolide, a sesquiterpene lactones isolated from the stems of *Schkuhria pinnata*, displayed the highest activity against the melanoma UACC62 cell line (TGI < 6.25 g/ml). Dichloromethane: methanol extract of *Artemisia afra* showed moderate activity against melanoma (SK-MEL-3M) and colon (HT29) strains [**20**]. Other metabolites that have shown antitumor properties include polyphenols and brassinosteroids.

Other miscellaneous activities: *Senecio asperulus* used in the treatment of mouth ulcers. The antimalarial activity of extracts of *S. pinnata* has promoted this plant as one of the most important herbs in the treatment of malaria in central Kenya. The powdered leaf of *S. pinnata* is swallowed with water as a remedy for ailments such as malaria, influenza and colds [**17**]. Other bioactivities from the literature are summarized in Appendix 2.

Conservation Status:

Surveys that are meant to establish the conservation status of Lesotho medicinal plants are scarce. Moreover, they are limited in scope and coverage. It turns out that South Africa is currently the only African country which has comprehensive data on conservation status of its flora. The current and only available information about the conservation of some Lesotho plants is in Lesotho Plant List 2002. The survey was limited to few plant families and species. Among the plant species in this review, *Dicoma anomala* is the only one that has a VU A2d status [4]. The authors are also informed that other subsidiary surveys were carried out for example, as part of Environment Impact Assessment (EIA) prior to the commencement of the Lesotho Highland Water Project. Only few plant species around the project area were evaluated. We have thus found it difficult to report the conservation status of the plants under study due to lack of adequate information.

The authors note that several initiatives by the government to protect the environment and biodiversity at large are in place. The government Policies, Bills, international Protocols and Acts have been ratified, and should be implemented without failure. The establishment of Katse Botanical garden, Sehlabathebe and Tsehlanyane National parks, Bokong Nature Reserve and the Liphofung Caves Cultural & Historical sites by the government is commendable. Again, institutional botanical gardens at the National University of Lesotho and Agricultural Research Unit of Lesotho Agricultural College are the right steps in the right direction

4. Conclusions

According to this review, the ethnobotanical information for the sampled species is satisfactorily preserved. Reported medicinal uses cover a wide range of ailments that include circulatory, gastrointestinal, respiratory, reproductive, pain relief, digestive and other non-classified sicknesses. Terpenoids (particularly sesquiterpene lactones) and several flavonoids derivatives are the main metabolites of this family. The observed biological activities are in agreement with the reported metabolites. Gaps do exist, however, in the isolation of active ingredients (compounds) and elucidation of their mechanisms of action. Undoubtedly, it is revealed that Asteraceae are very important in Lesotho traditional remedies. Cooperation in conservation strategies and policies is required at all levels, while ensuring that management initiatives take into account local market conditions and the socio-economic realities facing both consumers and those who depend on the trade for their livelihoods.

5. Conflicts of interest

The authors have no conflicts of interest.

6. Acknowledgements

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Producing Sustainable Clean Energy & Ensuring Sanitation Through Blackwater Management

Aiyuk, S.*, Khants'i B., Moeti T.

Department of Environmental Health, National University of Lesotho, Roma, Lesotho.

*** Corresponding author:** Phone: +266 5945 0338; E-mail: se.aiyuk@nul.ls

Abstract: This study determined the Chemical Oxygen Demand removal efficiencies of two Continuously Stirred Tank Reactors (CSTRs) from blackwater under anaerobic conditions, in order to generate sustainable clean energy. Two CSTRs were operated for a period of 100 days where they digested blackwater with cow dung acting as inoculum in reactor I (***RI***) and blackwater alone in reactor II (***RII***) that served as control set-up**.** They were both investigated at the hydraulic retention time (HRT) of 1.57days or approximately 38hours. ***RI*** had a maximum efficiency of 81% with biogas production of 1250mL and ***RII*** had a maximum efficiency of 65% with biogas production of 1030mL during the experimental period. such biogas could be employed for heating or electricity/power generation. This research points to the double advantage of using waste to produce clean renewable energy in the form of biogas. It also ensures removing the waste from the environment, thereby improving sanitation. Similar research should be conducted in order to meet sustainable development goals, particularly by ensuring availability and sustainable management of water and provision of adequate sanitation for all.

Keywords: Anaerobic digestion; CSTR; Blackwater; Renewable energy; Sanitation.

1. Introduction

Blackwater (sewage), comprised of greywater or sullage (domestic sewage) and toilet flushings, poses enormous challenges in its management. This is especially the case with developing countries, without adequate skills to design admirable innovative technologies for its management, together with the chronic problem of paucity in the required finances for their design, operation and maintenance. Environmental sanitation thus becomes a huge challenge, bringing environmental degradation and dire public health outcomes. Anaerobic technology can provide a cost-effective option for stabilising sewage [1,2] and an adapted Continuously Stirred Tank Reactor (CSTR) technology was developed and used for the anaerobic digestion of blackwater.

2. Methodology

The main research aim was to produce sustainable renewable clean energy, in the form of biogas (bio-energy), by using blackwater as a recycling substrate (feeding input) for adapted Continuously Stirred Tank Reactors (CSTRs) that are anaerobic technologies.

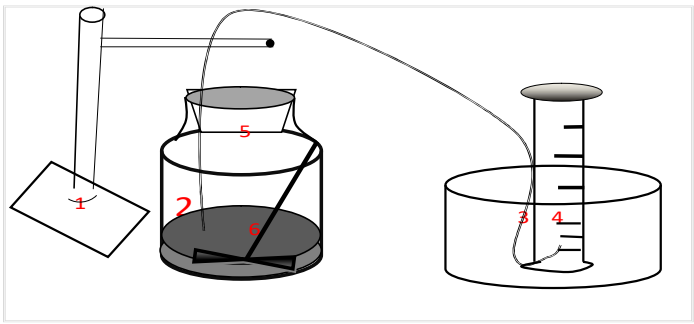

Figure 1. Schematic of major elements of a reactor set-up: 1-Retort stand, 2-CSTR tank, 3-Gas collector tube, 4-Graduated measuring cylinder, 5- rubber stopper, 6-Magnetic stirrer.

Figure 1 shows a sketch of one of the reactors and associated parts.

Forty two blackwater grab samples from the National University of Lesotho Roma campus (population about 9,500 students and staff) were collected over 90 days (3 months) in summer of 2017, for feeding two 2L anaerobic bioreactors (CSTRs). Samples were taken from the main collection manhole before the blackwater entered the campus pond system for treatment. Batch feeding (320mL influent) after equivalent effluent withdrawal (320mL) occurred daily at same time.

One reactor (RI) was spiked with 5g inoculum (cow dung) at start-up. Controlled operational parameters were used to ensure optimal anaerobic digestion through hydrolysis, acidogenesis, acetogenesis and methanogenesis: mesophilic temperature range (measured as 30-36°C during the summer study period), OLR of 2gCOD/L.d, VLR of 320mL/d, HRT of 38hrs. pH (4.6-8.5) was taken daily. Samples were stored at 4°C. Chemical oxygen demand (COD) was analysed thrice weekly, according to standard methods. Reactor efficiency was determined as: Efficiency (%) = ((Influent conc.- Effluent conc.)/Influent conc.)*100.

3. Results and Discussion

Figure 2 shows COD concentrations of influents and effluents for both CSTRs (RI and RII) over the experimental period. Figures 3 & 4 show COD removal efficiencies & collected biogas amounts, respectively. Influent COD concentrations ranged from 992-2464mg/L. Effluents ranged from 224-1568mg/L & 416-1152mg/L for RI & RII, respectively (figure 2). Computed COD removal efficiencies ranged from 15-81.1% for RI and 16-65% for RII (figure 3). RI produced 1250mL of biogas cummulatively, while RII produced 1030mL (figure 4). The higher COD removal efficiency & higher biogas production of RI could be

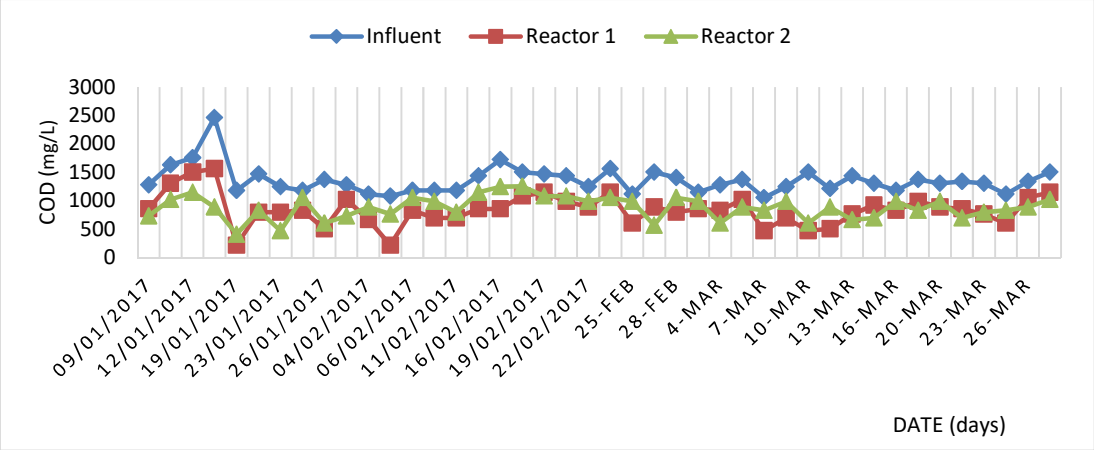

Figure 2. COD concentrations of influent & effluents after treatment.

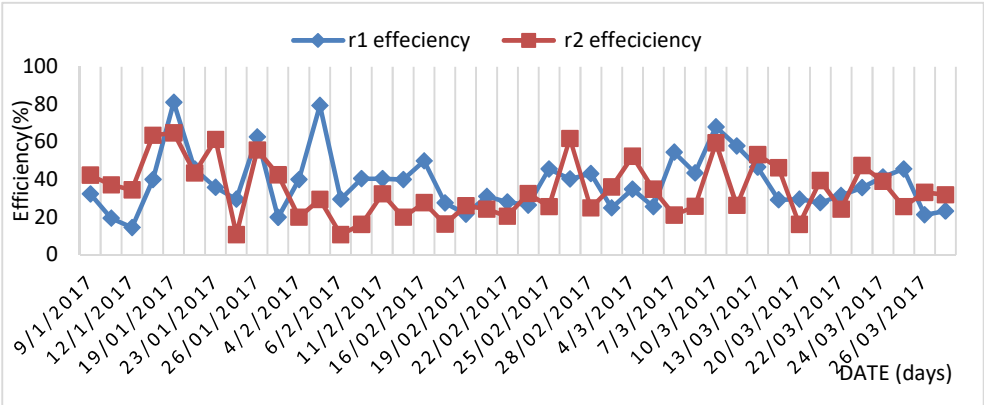

Figure 3. COD removal efficiencies.

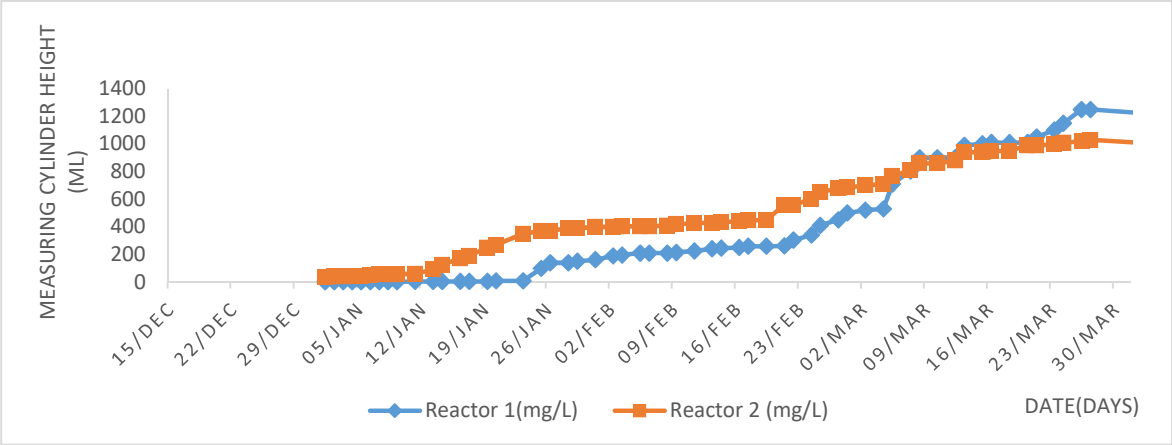

Figure 4. Amounts of biogas collected.

due to the inoculum spike of methanogenic bacteria. Overall, both CSTRs performed admirably, showing potential in bioenergy (biogas) production from sewage. Public health & the environment are also protected, as the sewage is also disposed of.

4. Conclusions

Blackwater was effectively used as input for an innovative technology to produce Sustainable, Renewable Clean Energy as biogas, for possible heating, electricity generation, etc. The design is simple, with high treatment output, ensuring an environmental cleansing (Sanitation) and protecting Public Health. This is an admirable wastewater recycling for energy generation that needs to be tested further.

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The VIP Latrine in Lesotho: Addressing Technical Flaws From the Qachas'Nek District Experience

S. Aiyuk[1,*], T. Siimane[1], R. Hlabana[1], K. Mothibe[2]

1 Department of Environmental Health, Faculty of Health Sciences, National University of Lesotho, PO Roma 180, Lesotho.
2 Department of Nutrition, Faculty of Health Sciences, National University of Lesotho, PO Roma 180, Lesotho.

[*]**Corresponding author:** Phone: +26659450338; E-mail: se.aiyuk@nul.ls

Abstract: Developing countries face a dilemma regarding the provision of adequate sanitation, especially for the poor, who constitute by far a greater proportion of the population. This is particularly so in rural and peri-urban areas, where sanitation is far from optimal, exposing communities to a plethora of communicable and other diseases, thus compromising public health and safety. In Lesotho, measures to address issues of sanitation, in the midst of a general scarcity, have led to the adoption of the cost-effective Ventilated Improved Pit (VIP) latrine, a technology used by over 80% of the population. This is especially so because Lesotho is one of the poorest countries in the world and is faced with abject scarcity of manpower and financial means for construction and maintenance of complex sanitary modern fixtures. However, the VIP latrine technology, commonplace as it is, is bedevilled by technical flaws that largely compromise its adequacy to handle basic sanitation. This led to an intervention that was made in the Qachas' Nek District, one of the ten Districts of Lesotho, where technological drawbacks inherent in the design and construction of the VIP latrine were addressed. From the lessons learned from this intervention, an extension was made to the Maseru District and elsewhere, where similar technical flaws were indentified and requiring interventions for rectification. Such interventions will help educate the communities and improve sanitation drives in the country.

Keywords: Sanitation; VIP latrine Technology; Community intervention; Lesotho.

1. Introduction

The Ventilated Improved Pit (VIP) latrine technology is a common fixture in developing countries like Lesotho, where the economies are weak and the provision of complicated sanitation drives is generally lacking, being especially the case with the rural communities. So, as developing countries face that dilemma regarding the provision of adequate sanitation, especially for the poor, who constitute by far a greater proportion of the population, there is therefore that need for adequate basic sanitation, in order to prevent the environmental pollution of the soil, water and air, thereby protecting public health, together with providing admirable aesthetics.

Lesotho is a mountain kingdom in the Sub-Saharan Africa, surrounded by its only neighbouring country, South Africa. It has a surface area of just over 30,000km^2, with a population of about 2 million inhabitants. It is one of poorest countries worldwide, with a mostly rural population that thrives mostly on subsistence survival through peasant agriculture and animal rearing. In the country, measures to address issues of sanitation, in the midst of this general scarcity, have led to the adoption of the cost-effective Ventilated Improved Pit (VIP) latrine, a technology used by over 80% of the population. This is in line with no manpower and financial means for the construction and maintenance of complex sanitary modern fixtures. Therefore, there is tremendous need to develop cheap reliable technologies that ensure basic sanitation adequately [1], especially with growing urbanization [2], leading to the proliferation of VIPs. This VIP technology, commonplace as it is, is bedevilled by technical flaws that largely compromise its adequacy, as identified in Qachas' Nek through a past project experience [3], and elsewhere in other Districts of the country.

It was therefore, as the main objective of this study, to also check the technical adequacy of VIP toilets in the Maseru District of Lesotho, following the study and intervention by Aiyuk and Tsepa in the Qachas' Nek District [3].

Another objective was to recommend the same kind of intervention as in Qachas' Nek that would bring positive change to impact livelihoods through

improved sanitation in the Maseru District and elsewhere.

2. Materials and Methods

The method used here was mainly a 'walk-around" and observations of existing VIP toilets in the Manonyane community of Roma, a small town that houses the National University of Lesotho.

3. Results and Discussion

A well designed and functioning VIP is as shown in figure 1 [3].
According to the authors, the VIP toilet is essentially a pit (~1m^3/capita and up to 4 meters deep) dug (sometimes 2 pits) into the ground, above which a concrete slab is built. A raised part of the slab has a hole, around which there is a toilet seat with a cover. There is a black vent pipe, at least 30cm above lowest part of roof, capped with gauze (mesh) with openings not more than 3 mm, to serve as a fly screen. The side with pipe faces sunrise. Such should be well sited, to avoid or minimize soil & water pollution. This technology has also been described by other authors [e.g., 4].
A convection current is created at the vent pipe as it is heated by the sun and warm air leaves through the pipe opening. The warm air is continually replaced by

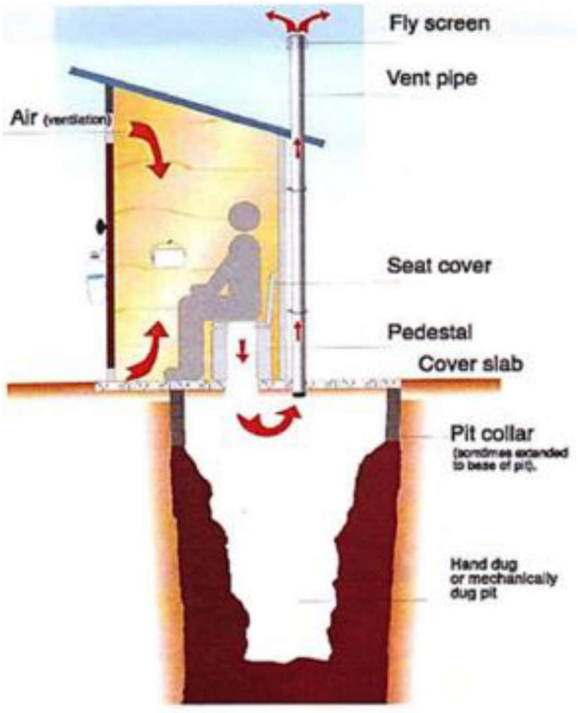

Figure 1. Typical VIP toilet cross section.

Figure 2. Back view of VIPs at a large hospital facility in Lesotho (note the white vent pipe and fly screen (capping pipe) with very large holes).

polluted air from inside the pit. The interior of the toilet thus remains smell free and cool.
With this study (figure 2), the following technical drawbacks were commonly observed:

- Most pipes are white in colour (not painted black) and are not high enough above the roof.
- Toilet walls were made of metal instead of hollow bricks, leading to a convection current flow in the opposite direction and rendering many of the toilets smelly inside.
- The mesh on the pipe vent has opening that are above 5mm, enabling flies and other vectors to move freely, posing thus a public health threat. Many other pipes in the District have no mesh at all.
- Back of superstructure with vent pipe not facing sunrise.
- Toilets not well sited in regard to water sources, leading to soil and water pollution.

There is thus the need to educate and train communities [5], and interact with decision makers, in order to reverse the problems with the VIP latrine technology and have a more long lasting effect.

4. Conclusion and recommendations

VIPs are on-plot sanitation systems that should keep the environment and public health protected, and also ensure aesthetics. The technology is admirable for basic sanitation as it presents simplicity, non-sophisticated equipment, high system output, minimal footprint size, and low capital and operational costs. However, in Lesotho, these toilets are not technologically sound and are usually not adequately sited vis-à-vis resources like water.
Therefore, from the Qachas' Nek experience, interventions should be made in the Maseru District and elsewhere, to redress the technological drawbacks. Such intervention will help educate the communities and improve sanitation drives in the country, saving the

environment, public health, and providing admirable aesthetics.

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Mineral Production & Processing and Associated Environmental Issues in Sub-Saharan Africa

M. Nete*, L. P. Mona, W. Purcell

Department of Chemistry, University of the Free State, Bloemfontein, 9300, South Africa

***Corresponding author:** E-mail: netem@ufs.ac.za

Abstract: Minerals are an important commodity and major contributor to the economies of some African countries. For example, in 2005 Zambia produced 19% Co, South Africa 89% platinum group metals, 23% vanadium while the sub-Saharan Africa (SSA) region accounted for 40% of diamonds, 20% of bauxite and 20% of rutile of the global supply. However, it is important to note that to date the mineral resources in the region have been insufficiently surveyed. Despite the mining potential and the resultant economic benefits many SSA countries still face many challenges to fully benefit from these resources due to different factors such as unstable political environments, labour unrests and sporadic power cuts in many of the countries. The aim of this work was to review mining activities in some SSA countries as well as the environmental issues associated with such mining practices.

Keywords: African minerals, mining, economy, environment, impact

1. Introduction

A mineral ore is a naturally occurring rock or sand which contains elements that are economically valuable. Mining involves the extraction of the mineral ore (Figure 1) from the earth's crust. After mining, the ore is processed to isolate minerals or individual elements with specific chemical compositions and constant physical and chemical properties. Many African countries are rich in mineral deposits such as zircon, columbo-tantalite, copper and cobalt minerals. For example, SA is the leading producer of PGMs and Zr minerals [1] while Namibia, Nigeria, Rwanda, Gabon, Mozambique, Democratic Republic of Congo and Zimbabwe make a significant contribution to the world's supply of columbite-tantalite (Ta/Nb) minerals [3].

Reports [4] indicated that in 2003 Africa possessed 16% of the world's Ta/Nb feedstock and that Nigeria, which is the dominant producer of niobium-containing minerals in Africa, possesses tantalite deposits which are extremely rich in Ta_2O_5 content (>40%) [5]. It was estimated that in 2009 approximately 50% of the world's supply of tantalum came from the DRC and Rwanda [6]. However, mining in the DRC, Rwanda and Zimbabwe is very risky due to the political instabilities in these countries and this makes the supply from these countries highly unreliable. It is generally believed that the illegal mining and the subsequent selling of coltan and gold from DRC supplies the finances to sustain the conflicts in this region and this has resulted in serious atrocities being committed against innocent people in that country. These conflicts not only led to the decline of social structures and economic activity in these areas but also to the destruction of the natural resources such as wildlife, endangering the continued existence of eco-sensitive species such as the African mountain gorilla.

Mineral exploration contribution to the African economies

In many SSA countries the mining industry is a cornerstone of the economy and it makes the largest contribution to job creation, foreign exchange earnings and other economic developments. However, mining

Figure 1. Copper mineral from the Democratic Republic of Congo.

has also had several negative environmental and social effects on the people of Africa (figure 2).

In most of African countries, mining still involves the extraction of mineral ore from the earth crust. Once extracted the ores are minimally processed and exported mostly as raw material with low earnings. Clearly these countries lack downstream technologies for processing of the mineral ores and as such lose large amounts of foreign investment and capital due to export of these valuable natural resources. The raw materials are processed to produce value-added products and the elements extracted from these minerals are used for many different applications in everyday life. Applications include steel production, medical, agricultural, aerospace and jewellery to name just a few. As such, mining and related industries are critical to some countries' socio-economic development worldwide. However, Haglund (2011) [7] warns about the high dependency of countries on the mining industry. According to Haglund, the highest dependency of mostly the low and middle income countries was observed during the rise of commodity prices.

Environmental impacts of mineral exploration in SSA countries

The environmental impacts associated with the mining industry derive mainly from the mine waste. The ore which is being mined, physical and chemical processes used to isolate the required mineral or element and the chemicals which are used in the process all determine the chemical composition of the waste that is being generated. Some waste produced in the metal processing industry has high concentrations of acids, cyanides and heavy metals, which have adverse impacts on the environment, human and animal health [8]. The dust from mine waste, fumes, heavy metals (e.g Pb and As) and radioactive metals (e.g. U and Th), may pose different health problems on flora and fauna in the vicinity of the mine waste. For example, dust from coal waste can causes black lung disease while dust from silica-containing waste may cause silicosis while that originating from asbestos can cause asbestosis. All these conditions can lead to death in human beings.

Another serious problem is the degradation of water quality from contamination by acid mine drainage. Chemical reactions of sulphide minerals, atmospheric oxygen and water lead to the formation of H_2SO_4 (Equation 1) which lowers the pH of water and thus negatively affecting the biodiversity of aquatic ecosystems and ultimately humans and animals through food-chain processes [9-10].

$$FeS_2 + O_2 + H_2O \longrightarrow Fe^{2+} + H_2SO_4 \qquad [1]$$

Production of waste in the mining industry is completely unavoidable and therefore proper measures for waste management have to be in place. The main requirement is to provide stable, safe and economical waste storages to protect the environment and human

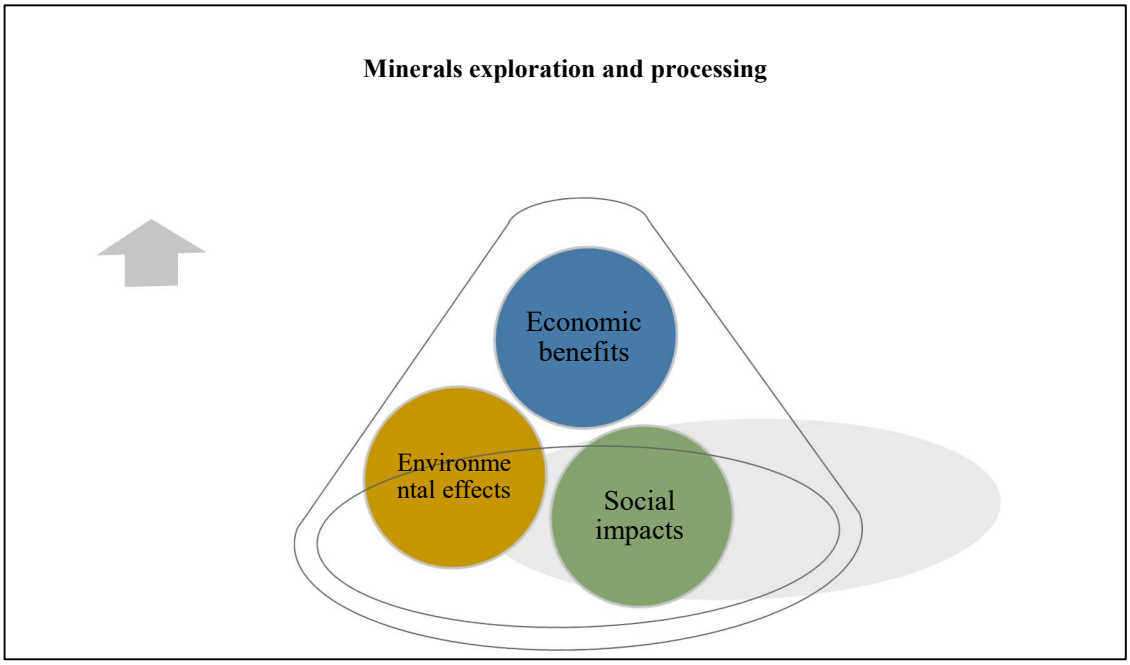

Figure 2. The economic, social and environmental effects of mineral exploration and processing.

health [11]. It is also encouraged that the mine wastes (both solid and liquid) be recycled and/or reused. However, it is important to note that not all waste or waste types can be recycled. Therefore, there has to be long-term management plan for such waste. There have to be plans and preparation for closure to ensure easy post-closure waste management. Preparations usually include growing of plants with high tolerance of toxic levels of heavy metals, covering the waste with a dry substrate such as alkaline materials to inhibit the sulphur and oxygen reactions that lead to formation of H_2SO_4 or covering the waste with clay soils to minimize the amount of water seeping through the solid into surface or groundwater.

Social impacts of mineral exploration in SSA countries

First, there were massive human migrations [12] across many SSA countries which were influenced by these non-renewable resources. The population growth in the many mining areas placed a strain on the infrastructure and services and this led to an increase in informal settlements in these areas. For example, in South Africa many mining area dwellers live in slums and poor environmental conditions such as poor air quality and dirty water run offs everywhere in the village. The economic deterioration in Zimbabwe has forced many Zimbabweans into illegal gold and diamond mining and consequently illegal trading of the minerals across the countries. This illegal exploration of minerals has led to destruction of roads, forests and water supply infrastructure as well as farmlands [13].

The recent increase in gold mines' closure in South Africa has left many communities which depended mostly on mining industry stranded. It is important to note that some of the mines were not closed due to depletion of the commodity, but also for other different reasons which include minimal or no profit due to high cost of production or for safety purposes. The abandoned mines which are not back-filled or protected otherwise attract illegal miners. The overall result of this illegal exploration of the mineral resource is conflicts and killings among the Africans. The Democratic Republic of Congo experienced the deadliest conflicts during the 1998 to 2003 period due to illegal mining and trading of gold and columbite-tantalite minerals. South Africa is currently experiencing high and mostly fatal accidents and crimes from the illegal miners ("Zamazamas" in local language). About 10% of South African gold is smuggled and sold out of the country, at a value of about R7-billion per year. The miners form part of a large syndicate group which runs the business as though it were legitimate at a high profit [14].

2. Conclusions

Mineral exploration and mining in Sub-Saharan Africa has come a long way and for a long time, has brought economic prosperities in countries such as Botswana and South Africa. The mining industry has been one of the major job creators in many African countries and with the new discoveries which continue to be made of mineral resources in countries such as Lesotho, there is more hope for the much needed economic developments in the region. However, there have not been much benefits of this exploitation of natural resources to many Africans due to high corruption in many African states and poor governance systems. In fact, more atrocities have been suffered in many of the mineral-rich countries as compared to the benefits.

While the mining industry is still the most important driver for economic developments it is important to take proper measures to protect the environment against the harmful waste from the mining activities. Of utmost importance is the attention which needs to be given to the illegal mining which leads to resources of states being exported unlawfully and ending of lives of citizens who are vulnerable because of their financial challenges. It is upon the ruling governments of states to pass strict laws to end crimes and for the mitigation of adverse impacts of waste on the environment and on health.

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The Effects of Traditional Medicines in Pregnant Women: A Case Study in Lesotho

Gertrude Mothibe[1*], Nomalima Tshabalala[2]

[1] *Pharmacy Department, Faculty of Health Science, National University of Lesotho, Roma, Lesotho.*
[2] *Medical Arts Pharmacy, Maputsoe, Leribe. Lesotho.*

[*]**Corresponding author:** Phone: (+266) 63735667; Email: gertiemothibe@gmail.com

Abstract: About 9% of pregnant women in Lesotho do not attend antenatal care services but use traditional medicines for their pregnancy related medical needs. Some attend the services but use the medication simultaneously with traditional medicines [1]. Although traditional medicines are natural, the safety, pharmacological effects and potential drug interactions of these products is not established and they may potentially harm both the mothers and unborn babies. The aim of this study was to establish the effects of traditional medicine in pregnant women. Interviewees were 20 pregnant women, 100 mothers, 10 midwives and 3 traditional healers. Results showed that 14% (n=120) of the women interviewed used traditional medicines during pregnancies. 88% (n=17) of the women who used the traditional medicines reported that the medicines had worked very well for them. 48% (n=120) women reported that they had refused recommendations from relatives and parents to use traditional medicines during pregnancy. Midwives reported negative effects of precipitate labour with women who use *pitsa,* and positive effects of induction of labour and shortened labour time. Traditional healers reported that *pitsa* helps prevent miscarriages and shortens labour. With these results, the researches recommend a laboratory based analysis of the traditional medicines used in pregnancy, for the purpose of clinically ascertaining the effects of these medicines on mother and child.

Keywords: Traditional medicine, Pregnant women, Anti-natal clinic, Labour, Trimester

1. Introduction

1.1 Background:

The World Health Organization (WHO) explains traditional medicines as products that are used based on traditional knowledge, beliefs and diverse health practices and approaches, including plant, animal and/or mineral based medicines, spiritual therapies, manual techniques and exercises applied singularly or in combination to maintain well-being, as well as to treat, diagnose or prevent illness. Traditional medicines have been an integral part of the practice of health care to improve health and well-being of people throughout the world, and are classified as complementary and alternative medicines (CAMs) [2]. It was from the very natural products where many useful therapeutic drugs were successfully developed in the past decades, especially the plant sources. Research and identification of a vast array of natural products with interesting biological activities have been the productive source of lead compounds in the development of new synthetic drugs [3].

In Lesotho traditional medicines have been used for centuries, for a vast array of purposes, in addition to those that are mentioned above. These include among others protection against witchcraft, magic, lucky charms and sorcery. As a measure of protection, a total of 303 plant species are in this case reported to be used medicinally. In some traditions, the pregnant woman takes a concoction called *pitsa* orally from the time the family knows about their pregnancy until the last trimester [4] [5].

1.2 Problem statement:

Most pregnant women in Lesotho do not attend antenatal care services but use traditional medicines instead [1]. Some attend the services but they use the medication from the clinics simultaneously with traditional medicines . Although traditional medicines are natural, the safety, pharmacological effects and potential drug interactions of these products are not established and they may potentially harm both the mothers and unborn babies.

Some women are aware of the importance of antenatal care services but are however torn between the advice of the nurses and that of their own parents. Cultural beliefs drive parents to advice their daughters to take traditional medicines, “for the wellbeing of the baby”, or “for protection against evil”.

On the other hand, financial problems, limited availability of health care services, long distance from health facilities and poor road conditions, especially for women living in remote areas, hinder women from attending proper antenatal care services [6]. Moreover, wrong information, beliefs and superstitions about modern medicines are reported to influence the use of traditional medicines during pregnancy instead of doctors' prescribed medicines.

1.3 Study justification:

This study intends to stir up cognizance among the public, modern health care personnel, and traditional practitioners that it is important for them to all unite to address issues concerning reproductive health.

1.4 Research objectives:

The aim of this study is to establish the effects of traditional medicines in pregnant women for purposes of educating the public, traditional doctors and modern health professionals.

1.4.1 Specific objectives:

- To find out why Basotho women use traditional medicines in pregnancy
- To investigate the prevalence of the use of traditional medicines among pregnant Basotho women.
- To find out if there are any dangerous effects of traditional medicines in pregnant women.
- To create awareness that there should be collaboration between traditional doctors and modern health workers as far as reproductive health is concerned.

2. Material and Methods

2.1 Methodology:

The study was conducted in Leribe, Motebang hospital and surrounding villages, Roma valley, St Joseph's hospital., as a qualitative study using questionnaires, phone call interviews, and individual person interviews to collect data.

Pregnant women from around Roma who attended antenatal health services at St Joseph's Hospital in May 2017, and from around Leribe, those who attended at Motebang Hospital in March 2017, were interviewed. Women were also included in this study who were in the maternity wards (antenatal and postnatal wards), in the above hospitals. Midwives and traditional healers also took part in this study.

The sample was 20 pregnant women, 100 mothers, 10 health professionals (midwives) and 3 traditional healers, from around the above mentioned places that were willing to participate.

Convenience sampling method was used; participants were individuals who were available and willing to participate.

2.2 Ethical issues:

- Ethical approval was obtained from the Internal Review Board of the National University of Lesotho, and then from the Ministry of Health.
- Confidentiality of the interviewees was taken into consideration
- Consent was sought from all participants.
- Approval was obtained from the hospitals to conduct the study in these institutions.

3. Results and Discussion

3.1 Why Basotho women use traditional medicines during pregnancy:

Traditional antenatal care: One traditional doctor reported that the concoction contains a herb called *sehlapetso*, taken every day during the first trimester, then more ingredients are added as the pregnancy progresses. She explained that a vast array of plants (e.g. *qobo*, *khamane e kholo* and a mixture of *mahorametsa*, and *phakisane*) and other natural products (e.g. horse's uteral lining) are used as a concoction. Different people use different mixtures, depending on which part of the country they live in, and which plants are available around them. These traditional remedies are used to protect the mother and baby from evil and witchcraft, to make a healthy baby, to avoid complications during pregnancy, and to attain quick and easy delivery.

3.2 The prevalence of the use of traditional medicines among pregnant Basotho women:

A total of 10 midwives from Leribe and Roma were interviewed, all of whom admitted that they have encountered at least 3 to 5 cases of women who had used traditional medicines during their pregnancy per month. They reported that this was discovered mostly during labour, when the effects were manifested.

17 out of 120 women (14%) who took part in the study were found to have used traditional medicines for pregnancy related matters during their past or present pregnancies. 15 out of the 17 (88%) reported that the medicines had worked very well for them. 2 pregnant women however had not started attending antenatal care services yet, they said it was still early in their pregnancy, and they would start later. 58 out of the 120 (48%) women reported that they had denied recommendations from relatives and parents to use traditional medicines during their medicines.

3.3 Effects of traditional medicines in pregnancy:

Midwifes reported that there are positive, and negative effects to the use of traditional medicines during pregnancy, and there are seemingly more undesirable than desirable effects. None of the women who accepted that they had used traditional medicines during pregnancy however reported having experienced any problems.

Dangerous effects of pitsa, as reported by nurse midwives

Precipitate labour: Normally, the birth of a baby occurs in three stages, active labour, birth of the baby, and delivery of the placenta. On average, the stages of labour last for 6 to 18 hours but precipitate labour is characterised by a sudden of intense, closely times contractions and a delivery that occurs very shortly after labour has begun; less than 5 hours, or as little as 3 hours. This is common among Basotho women, who use pitsa.

Precipitate labour may result in complications such as extensive tearing of the birth canal leading to extensive bleeding after birth (post-partum haemorrhage), failure of the uterus to contract back to normal size. Sometimes uteral rapture occurs and if not detected early, the woman may bleed to death.

Precipitate labour does not only harm the mother, but it also harms the baby. Due to the rapid exit through the birth canal, the baby may experience difficulty in breathing. The heart activities of the baby may also be affected, leading to foetal distress.

Changing the position of the baby**:** Traditional medicines are said to change the position of the baby. This is a disadvantage if the baby is already in the right foetal position, because it might result in a breech position. In this case a caesarean delivery is recommended, but it gets difficult if the patient is in precipitate labour because then there is no time to go to theatre.

Positive effects of pitsa: Some nurse midwives reported that this concoction seemed to work wonders for some women as far shortening and inducing labour is concerned.

3.4 Common contents of pitsa and what they are believed to do:

Sehlapetso - It is given in the first trimester for the treatment of heartburn, and to protect the baby from evil plots.

Khamane e kholo- This plant is boiled and taken orally to prevent nausea and vomiting

Phakisane - The English translation of the word is “to quicken”. This plant was named after the fact that is speeds up the labour process

Mohlana wa pere and *Qobo* - These are cooked together and taken in the 8th month of pregnancy, they are said to help shorten the labour and help the baby come out fast and easily.

Phethola - It is believed to help turn the baby and it is given in the second trimester of pregnancy. It is named after the action of turning.

4. Conclusion and Recommendation

Traditional medicines are effective when they are used for pregnancy related conditions. They, however, lack dosing limitations and have not been tested for safety in pregnancy, as a result pregnant women may consume dangerous amounts unknowingly and experience undesired effects. It is thus recommended to conduct a laboratory based analysis of the traditional medicines used in pregnancy, for the purpose of identifying the active molecules and scientifically ascertaining the effects of these medicines on mother and child.

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Synthesis and Characterization of Copper Oxide Nanoparticles and their Application as Electrode Modifiers

Hailemicheal Alemu[1], Lineo F. Maxakaza[1], Himanshu Narayan[2,*]

[1] *Department of Chemistry & Chemical Technology, National University of Lesotho, Roma 180, Lesotho.*
[2] *Department of Physics & Electronics, National University of Lesotho, Roma 180, Lesotho.*

[*]**Corresponding author:** Phone: (+266) 5221 3521; E-mail: h.narayan@nul.ls

Abstract: Nano-sized copper oxide (CuO) powder was synthesized through the method of wet chemical precipitation from $Cu(NO_3)_2$. The nanoparticles were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), particle size analyzer and Fourier transform infra-red spectroscopy (FTIR). Two most prominent peaks in the XRD profile, around $2\theta = 35.9°$ and 39.2°, which are combinations of double-reflections {(002) and (-111)} and {(111) and (200)}, respectively, are characteristics of monoclinic CuO. The unit cell parameters determined from the analysis of XRD data were: $a = 4.6927$, $b = 3.4283$ and $c = 5.137$ Å, with $\alpha = \gamma = 90°$ and $\beta = 99.546°$. SEM pictures showed uniform distribution of ice-glass like crystalline particles, which are made up of smaller particles. Crystallite size estimation from XRD data using Debye-Scherrer formula produced average size of 34 nm for the nanoparticles. However, the particle size analyzer measured the average grain-size as 86 nm. Clearly, each grain of the nano-sized CuO seemed to be made up of roughly 16 crystallites. FTIR results showed expected peaks corresponding to Cu-O stretching. Further, the electrocatalytic properties of CuO nanoparticles as carbon paste electrode (CPE) modifier were investigated for the electrochemical oxidation of ascorbic acid, atenolol, diclofenac, dopamine, hydrazine and glucose using cyclic voltammetry. The results showed marked improvement of detection efficiency with CuO nanoparticles modified carbon paste electrode as compared to the response of the unmodified carbon paste electrode.

Keywords: Copper oxide; Nanoparticles; Voltammetry; Modified carbon paste electrode.

1. Introduction

Nano-sized and nanostructured transition metal oxides have attracted considerable attention from researchers in the recent years. Oxides such as ZnO, TiO_2 and Fe_3O_4, etc. are perhaps the most investigated inorganic materials due to their interesting physical and chemical properties. Copper (II) oxide, CuO, also known as cupric oxide is a p-type semiconductor with a bandgap of 1.2 – 1.9 eV. It is a black transition metal oxide with monoclinic crystal structure and many interesting characteristics, e.g., high thermal conductivity, photovoltaic properties, high stability and antimicrobial activity. Because of such useful properties, CuO has been investigated extensively for its wide range of potential applications, such as, in electrochemical cell, gas sensors, magnetic storage devices, field emitters and in catalysis [1].

Carbon paste electrodes (CPEs) are widely used for the electrochemical determinations of various biological and pharmaceutical species due to their low residual current and noise, ease of fabrication, wide anodic and cathodic potential ranges, rapid surface renewal and low cost. Moreover, chemically modified carbon paste electrodes (CMCPEs) can be easily prepared by adding different substances to the bulk of CPEs in order to increase sensitivity, selectivity, and rapidity of determinations.

In the past few decades, nanoparticles of a variety of shapes, sizes and compositions exhibit excellent conductivity and fascinating catalytic properties, which make them suitable for constructing novel electrochemical sensors. Nanocomposites can significantly improve the electrocatalytic properties of substrates, decrease the overpotential, increase the reaction rate and improve reproducibility of the electrode response in the area of electroanalysis [2]. Appropriate modifications of the electrodes are generally required for improved performance and efficiency of electrochemical cells, in photovoltaics, and applications as sensors and detectors. CuO nanoparticles and nanostructures, in pure and in combination with other materials, have been proven to be interesting candidates for carbon paste electrode

modifiers [2-5]. A variety of methods have been reported for the preparation of nanocrystalline CuO particles, which include the sol-gel technique [1], sonochemical method [6], electrochemical method [7], microwave irradiation method [8], wet chemical/alcothermal method [9], solution-plasma method [10], etc.

In this report we present the synthesis of CuO nanoparticles using wet chemical precipitation (WCP) method, using $Cu(NO_3)_2$ and 1,10-phenanthroline as precursors, and ethanol/water mixture and NaOH as a reducing agents. Characterization of the synthesized CuO nanoparticles have been done by X-ray diffraction (XRD), Fourier Transform Infra-Red spectroscopy (FTIR), thermogravimetric analysis (TGA) and particle-size analysis. Further, their potential application as electrocatalysts has been examined using them as carbon paste electrode modifiers by cyclic voltammetry (CV) for the detection of ascorbic acid, atenolol, diclofenac, dopamine, hydrazine and glucose.

2. Experimental

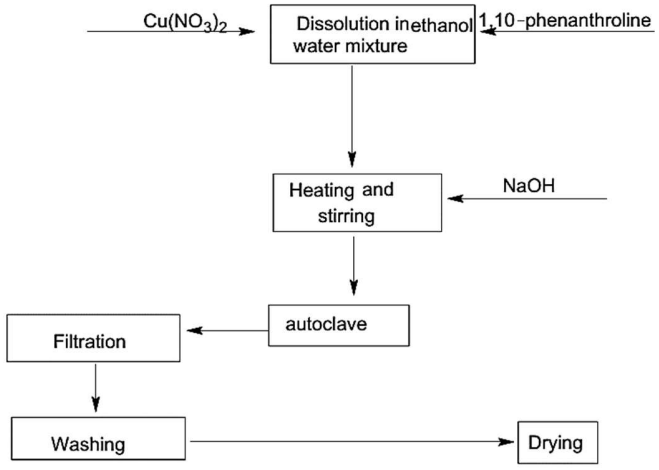
Synthesis of CuO nanoparticles:

NaOH was obtained from ACE (South Africa), 1,10-phenanthroline from Saarchem (South Africa), ethanol from Laboratory & Analytical Suppliers Co. (Pty) Ltd (South Africa), glucose from Merck-Schuchardt (Germany), $Cu(NO_3)_2$ from NT Laboratory Suppliers (Pty) Ltd (South Africa), ascorbic acid from Merck Chemicals (South Africa), hydrazine, atenolol, dopamine and diclofenac were from Fluka. All reagents were used as received and ultra-pure water was used throughout. Stock solutions of 0.01 M solutions of ascorbic acid, atenolol, diclofenac, dopamine, hydrazine and glucose were prepared and diluted as required. Phosphate buffer of pH 7 (supporting electrolyte was prepared from stock solution of 0.1 M disodium hydrogen phosphate and 0.1 M HCl. $Cu(NO_3)_2$ 3 mM and 1,10-phenanthroline 6 mM were prepared in 1:1 ethanol/water mixture. 2 M NaOH aqueous solution was then added to the solution under magnetic stirring and heating. The alkaline solution was transferred into an autoclave. The autoclave was then sealed and maintained at 160 °C for 24 h. The solution was then cooled to room temperature, the black precipitates were filtered, washed with water and absolute ethanol for several times and then dried in an oven at 50 °C.

Figure 1 shows the synthesis route and reactions for the preparation of CuO nanoparticles. In reaction R1, water displaces the nitro group because it is a stronger ligand, resulting in a blue complex of $Cu(H_2O)_6^{2+}$. The same is true for reaction R2 [11]. 1, 10-phenanthroline is an organic compound that enhances formation of individual nanowires, a flower of nanowires agglomerated together would otherwise result if it was not used. It does not take part in the chemical synthesis of the reaction.

Instruments:

X-ray diffraction measurements were executed with a Shimadzu D6000 Diffractometer (from Shimadzu,



$$Cu(NO_3)_2\,(s) + H_2O\,(l) \rightarrow Cu(H_2O)_6^{2+}\,(aq) + NO_3^{2-}\,(aq) \quad \text{R1}$$

$$Cu(H_2O)_6^{2+}\,(aq) + 2OH^-\,(aq) \rightarrow Cu(OH)_2\,(s) + H_2O\,(l) \quad \text{R2}$$

$$Cu(OH)_2\,(s) + \text{heat} \rightarrow CuO\,(s) + H_2O\,(l) \quad \text{R3}$$

Figure 1. Synthesis route of CuO nanoparticles and chemical reactions.

Japan) using Cu K_α radiation (λ = 1.5406 Å) in the 2θ range from 20° to 60°. Scanning electron microscopy (SEM) was carried out on a Zeiss crossbeam series with Gemini FESEM unit. Fourier transform infra-red (FTIR) spectroscopy was carried out with Shimadzu FTIR, run from 400 cm^{-1} to 4000 cm^{-1} using diffuse reflection method, and KBr pellet was used for background measurement. Thermogravimetric analysis (TGA) was carried out with SDT 2960 Simultaneous DSC-TGA, TA Instruments from 24°C to 700°C at a ramp of 10°C/min. Particle size analysis was performed using Microtrac/Nanotrac TM150, which employs optical light scattering of particles suspended in water. Cyclic voltammetry measurements were done using BAS 100B Electrochemical Analyzer [Bio-analytical Systems (BAS), USA] and a one component glass cell vial with a three electrode configuration. Electrodes used were platinum wire counter electrode, Ag/AgCl (3M NaCl) reference electrode and CuO modified and unmodified CPE working electrode. The pH of the buffer solutions was measured with a Hanna Instruments digital pH meter.

Preparation of unmodified and CuO nanoparticles modified CPE:

Unmodified CPE was prepared by hand mixing 2.0 g carbon powder with a few drops of mineral oil. After mixing in an agate mortar, the resulting paste was packed into a 3 mm diameter cavity of a syringe and electrical contact was established via a copper wire. The electrode surface was gently smoothed by rubbing against a glass block. A 15% CuO modified CPE was prepared from 0.30 g CuO nano-particles, 1.7 g graphite and few drops of mineral oil in the same manner as above. The same procedure was used to regenerate the surface of the electrodes.

Cyclic voltammetry procedure:

10 cm^3 of the supporting electrolyte i.e., 0.1M phosphate buffer pH 7.0 was placed in the electrochemical cell, stirred for 30 seconds and CV of the supporting electrolyte was run from 0 mV to 600 mV and back. Thereafter the electrolyte was spiked with the solution of the electroactive compound that is intended for the study, stirred and CV was run in the same potential range. All measurements were done at room temperature.

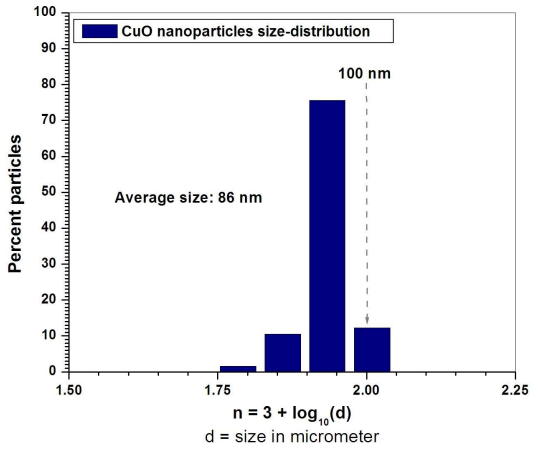


Figure 3. Particle size distribution of CuO nanoparticles.

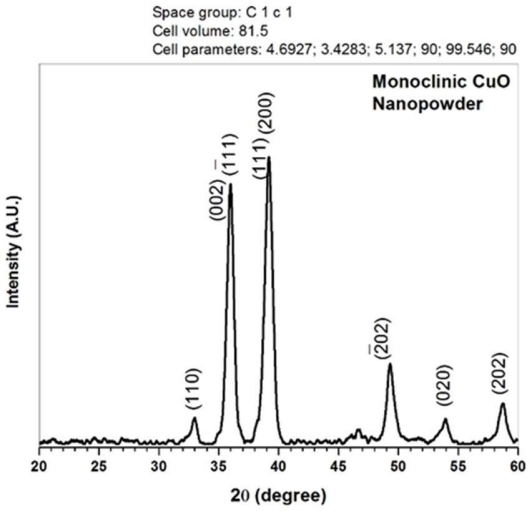


Figure 2. X-Ray Diffraction spectrum of CuO nano-powder.

3. Results and Discussion

X-ray diffraction analysis of CuO nanopowder:

X-ray diffraction pattern of nano-sized CuO is shown in figure 2. A detailed Reitveld analysis of XRD data to determine the crystal structure was also performed using FullProf Software Suite [12]. The two most prominent peaks around 2θ = 35.9° and 39.2°, which were identified as combinations of double-reflections {(002) and (-111)} and {(111) and (200)}, respectively, are characteristics of CuO. Further the acceptable FullProf solution after several trails produced monoclinic unit-cell with Cc space group and cell parameters: a = 4.6927 Å, b = 3.4283 Å, c = 5.137 Å, α = 90°, β = 99.546° and γ = 90°. These results are in very good agreement with the already reported single crystal data for CuO [13]. It is also noteworthy that the actual peaks recorded for the CuO nanopowder are apparently shifted approximately by +0.3° of 2θ value, which may be tentatively attributed to the strains within the crystallites.

Particles size analysis:

Average crystallite size of 34 nm for the CuO nanoparticles was estimated using Debye-Scherrer method. FWHM of the Gaussian best-fit to prominent peaks in the XRD data was used in the formula.

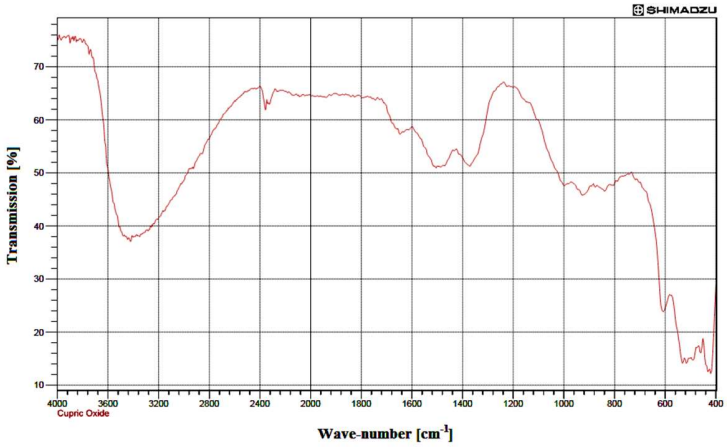


Figure 5. IR spectrum of CuO nanoparticles.

Though this method has its own limitations, it immediately gives a rough estimation of the size without much effort. Since the X-rays penetrate through the surface of the particles, what is measured here is the size of small crystallites within the grains that diffract X-rays coherently [14].

On the other hand, the grain-size was measured on a particle size analyzer. A solution of copper oxide was prepared with pure water and agitated in an ultrasonic bath to obtain an evenly dispersed solution. Instrument was set to zero using the solvent (water) then the CuO solution was filled in the cell and measured. Distribution of grain-size obtained is shown in figure 3. The mean grain size of CuO nanoparticles was determined to be 86 nm by the particle size analyzer, which measures the average diameter of the grains using light as a probe. Obviously, light cannot penetrate through the surface and therefore, this method gives the size of individual grains that could possibly be made up of several crystallites.

A comparison of volumes created by the two sizes reveals that apparently each grain consists of approximately 16 crystallites, on an average.

Scanning electron microscopy:

SEM pictures at two different magnifications are shown in figure 4. Highly crystalline, broken glass like structures are clearly visible in the pictures. The observed white spots in the SEM pictures are presumably traces of 1,10-phenanthroline left after washing. Moreover, the energy dispersive X-ray spectroscopy (EDX) carried out on the same machine established the composition of the nanoparticles as CuO.

FTIR and TGA:

Figure 5 shows the FTIR spectrum of CuO nanoparticles. Characteristic peaks of CuO range from around 400 cm^{-1} to 1000 cm^{-1}. Peaks around 420 cm^{-1}, 500 cm^{-1} and 610 cm^{-1} can be assigned to Cu–O stretching along [–202] Cu–O direction. Small sharp peak around 450 cm^{-1} is attributed to Cu–O stretching along [202] direction. The peak around 2300 cm^{-1} can be assigned to CO_2 stretching, which could have been entrapped in the sample holder during packing. The broad peak around 3500 cm^{-1} is due to O–H stretch and bending from adsorbed water.

Thermogravimetric analysis of 8.4 mg of CuO nanoparticles was run from 24 °C to 700 °C at a ramp of 10 °C/min (picture not shown). It shows that in the

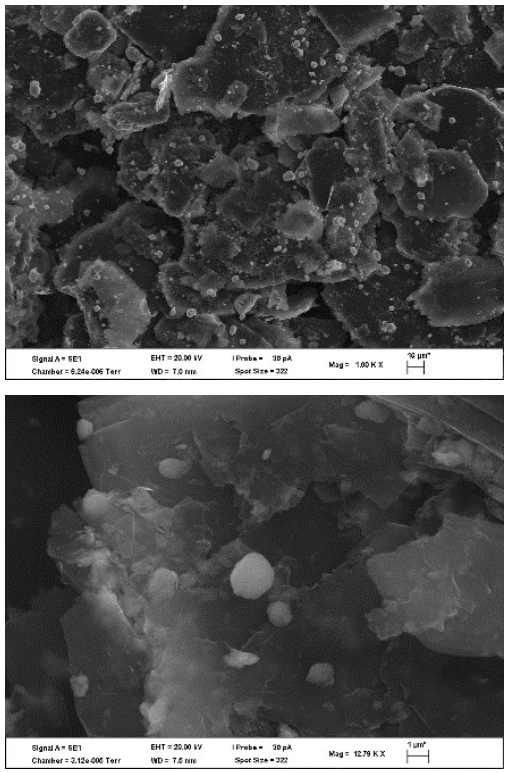


Figure 4. SEM pictures of CuO nano-particles.

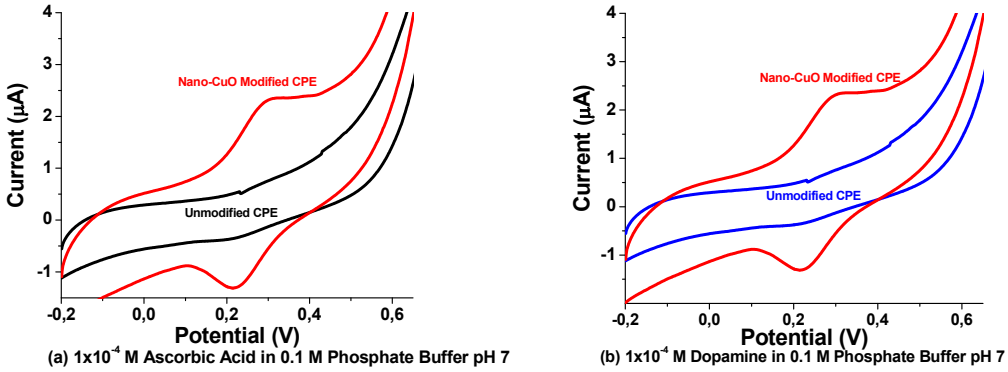


Figure 6. Detection of 1 x 10^{-4} M ascorbic acid (a) and 1 x 10^{-4} M dopamine (b) with unmodified CPE and CuO nanoparticle modified CPE, respectively.

temperatures range of 80 – 140 °C, the percentage weight loss with temperature is about 1.0 %. This can be attributed to loss of adsorbed water and ethanol, 2.0 % weight loss around 260 – 340 °C with is attributed to loss of hydroxyl ions. Weight percentage remains fairly constant above 500 °C, thus most impurities were lost at this temperature. The total weight loss is about 3 %. It can therefore be concluded that CuO nanoparticles are stable at elevated temperatures.

Electrochemical response of CuO nanoparticles modified CPE:

The electrochemical responses of CuO nanoparticles modified electrode were studied for the detection of ascorbic acid, atenolol, diclofenac, dopamine, hydrazine and glucose using cyclic voltammeter. Figure 6 shows the cyclic voltammograms of 1 x 10^{-4} M ascorbic acid (a) and 1 x 10^{-4} M dopamine (b) with unmodified CPE and CuO nanoparticles modified CPE, respectively, at a scan rate of 50 mV s^{-1} in 0.1 M phosphate buffer of pH 7. As can be seen from the voltammograms, At the unmodified carbon paste electrode, ascorbic acid and dopamine do not show detectable oxidation peaks while each of them show well undefined cathodic peaks. When 15% CuO nanoparticles modified CPE was used as the working electrode, both compounds gave well defined anodic and cathodic peaks with measurable currents, respectively. Similar voltammograms were also obtained for atenolol, diclofenac, hydrazine and glucose (figures are not shown).

It can be observed that the detection of these compounds improves with the use of CuO nanoparticle modified CPE relative to the unmodified CPE. The observed anodic and cathodic currents for all the studied compounds prove the electrocatalytic properties of the synthesized CuO nanoparticles.

4. Conclusions

Synthesis, characterization and application as a carbon paste electrode modifier of nano-sized copper oxide (CuO) powder has been reported. Prominent XRD peaks around 2θ = 35.9° and 39.2°, which are combinations of double-reflections {(002) and (-111)} and {(111) and (200)}, respectively, have been identified as the characteristics of monoclinic CuO, with unit-cell parameters estimated as: a = 4.6927, b = 3.4283 and c = 5.137 Å; $\alpha = \gamma = 90°$, β = 99.546°. Moreover, the crystallite size calculated from XRD data through Debye-Scherrer method produced average size of 34 nm for the nanoparticles. The average grain-size measured on particle size analyzer however was 86 nm. Therefore it was concluded that each grain of the nano-sized CuO was apparently made up of nearly 16 crystallites. Uniform distribution of ice-glass like crystalline particles was visible in SEM pictures, which were agglomerations of smaller particles. FTIR results confirmed the stretching of Cu-O bonds as expected. Finally, the electrocatalytic properties of CuO nanoparticles as carbon paste electrode modifier were also investigated for the electrochemical oxidation of ascorbic acid, atenolol, diclofenac, dopamine, hydrazine and glucose using cyclic voltammetry. The results showed significant improvement of detection efficiency in the carbon paste electrode modified with CuO nanoparticles, as against the response of unmodified carbon paste electrode.

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Eco-Friendly Synthesis of Zinc Oxide Nanoparticles for Rayon Pulp

Amrita Singh[1], Brijesh Gaud[1], Himanshu Narayan[2], Rinkesh Kurkure[3], Sandesh Jaybhaye[1,*]

[1] *Nanotech Research Lab, Department of Chemistry, Birla College, Kalyan, India.*
[2] *Department of Physics & Electronics, National University of Lesotho, Roma 180, Lesotho.*
[3] *TernaCollege of Engineering, Nerul, Mumbai, India.*

[*]**Corresponding author:** Phone: (+91) 9869566808, 0251-2230054; Email: jaysandesh@gmail.com

Abstract: Various methods have been employed not just to synthesize but also to improve the size and properties of the Zinc oxide (ZnO) nano particles (NPs) so as to enhance its performance. We report synthesis of ZnO NPs through bio-reduction of zinc-nitrate using neem (*Azadirachta indica*) plant extract. Characterization was done through FT-IR, UV-vis spectroscopy, XRD, AFM and SEM. Peak around 513 cm^{-1} in the FT-IR spectra indicated characteristic absorption of ZnO. UV-Vis absorption spectra showed a typical ZnO profile with peak-wavelength around 352 nm. The SEM images show that ZnO NPs prepared in this study are spherical in shape with smooth surface. The size of the NPs was determined from SEM, as well as AFM pictures, and was estimated to be within 16 – 40 nm. As a potential application, a qualitative analysis of antibacterial activity of ZnO NPs for rayon pulp was also carried out, and the results obtained were found promising.

Keywords: ZnO NPs, Bio-Reduction, Chemical and Physical Methods, Anti-bacterial activity, Rayon

1. Introduction

Today, nanotechnology is operating in various fields of science via its operation for materials and devices using different techniques at nanometer scale. Nanoparticles are a part of nanomaterials that are defined as a single particles 1–100 nm in diameter. From last few years, nanoparticles have been a common material for the development of new cutting-edge applications in communications, energy storage, sensing, data storage, optics, transmission, environmental protection, cosmetics, biology, and medicine due to their important optical, electrical, and magnetic properties.

Nanotechnology concerns with the development of experimental processes for the synthesis of nanoparticles of different sizes, shapes and controlled disparity. This provides an efficient control over many of the physical and chemical properties with various potential applications including pharmaceuticals and medicine.

Recently, ZnO nanoparticles have received considerable attention due to their unique remarkable chemical and physical properties that are distinctive from those of conventional bulk materials. To date, various methods have been adopted for the preparation of ZnO crystallites including sol–gel method, evaporative decomposition of solutions, gas-phase reaction, wet chemical synthesis and hydrothermal discharging gas method. However, these methods usually involve high temperatures and sometimes complicated processes, which might result in impurities in the final products.

Rodrigues-Paez et al. synthesized zinc oxide nanoparticles with different morphologies by controlling different parameters of the precipitation process such as solution concentration, pH, and washing medium.

In the last few decades, with the increase in new antimicrobial fiber technologies and the growing awareness about cleaner surroundings and healthy lifestyle, a range of textile products based on synthetic antimicrobial agents such as triclosan, metal and their salts, organometallics, phenols and quaternary ammonium compounds, have been developed and quite a few are also available commercially. In the present study, ZnO nanostructures have been synthesized by Bio-Reduction of Zinc Nitrate in plant extract method. Zinc nitrate heptahydrate and plant extract were used as precursors to formulate ZnO nanostructures.

Bio-Reduction of Zinc Nitrate in plant extract for synthesis of ZnO nanostructures has many advantages such as fast crystallization, cost efficiency and low waste production. The prepared samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and atomic force microscopy (AFM), and the purity of the sample was tested by FTIR spectroscopy and UV-Visible spectroscopy. Antimicrobial activity was analyzed using ZnO NPs in rayon pulp. The rayon fabric showed no antibacterial activity against both Gram positive and Gram negative bacteria. The results show excellent antibacterial activity of the ZnO NPs in Rayon pulp samples.

2. Experimental

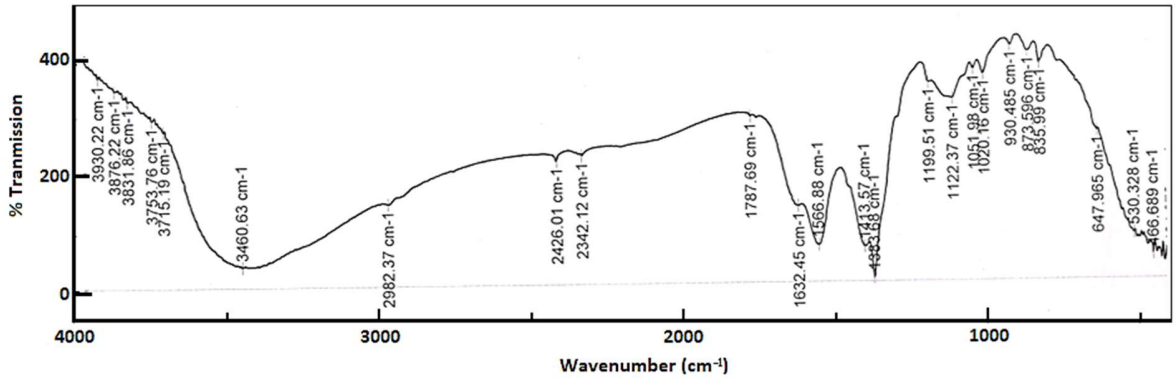
Hot water extraction:

The Neem (*Azadirachta indica*) Leaves were washed with sterile double distilled water to remove the surface contamination and dried in shadow. The dried plant material was cut into in small pieces. 5gm of plant material was taken and mixed with 100 ml of sterile double distilled water and kept in water bath for reflux at 100 ºC for 60 minutes. The obtained reflux solution is then filtered by Whatman No. 1 filter paper. The filtered extract was stored in refrigerator at 20 ºC for further studies.

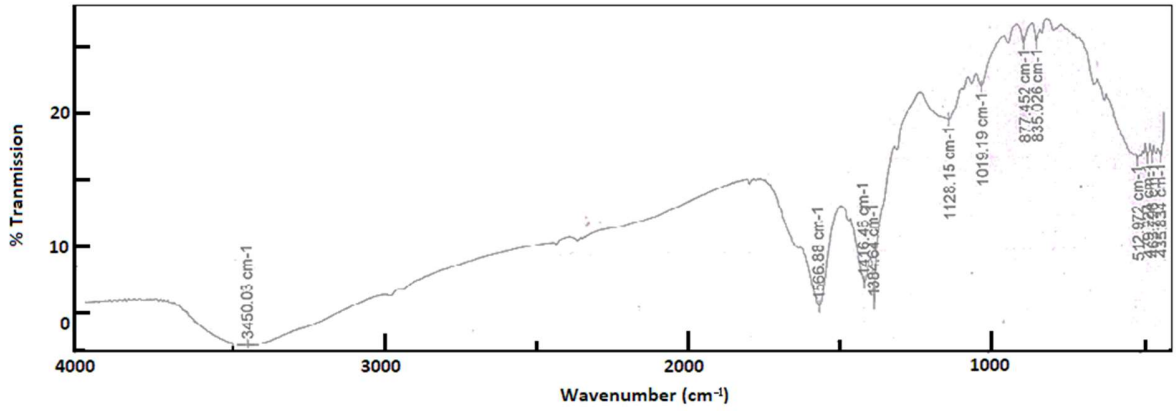
Figure 1. Preparation of ZnO NPs: Change of colour during the course of reaction.

Biosynthesis of ZnO NPs:

The biosynthesis of ZnO NPs, 15 cm^3 of plant extract



(a)



(b)

Figure 2. FT-IR Spectra of (a) Plant extract, and (b) ZnO NPs.

having pH 5 was mixed with 15 ml of 4.0 mM aqueous zinc nitrate solution, at temperature 60 ºC and put for sonaication for 30 Minute. The bio-reduction of the Zinc ions in the solution was monitored periodically by measuring the UV-Vis spectroscopy (200–800 nm) of the solutions. Fig.1 shows colour changes for the preparation of ZnO NPs was observed during the course of the reaction. Initially, the solution is yellow, but over 30 minutes the solution turned Yellowish brown. The formation of a yellowish brown coloured solution indicated the formation of the ZnO NPs. The ZnO NPs obtained was centrifuge and then obtain ZnO NPs were purified by sterile deionized water several times to remove the water-soluble biomolecules such as proteins and secondary metabolites. After that dried ZnO NPs were used to characterize the structure and composition.

Instruments:

FTIR was carried out on a JUSGO unit and XRD measurements were performed on MiniFlex machine with Cu-K_α radiation (λ = 1.54178 Å) at 40 kV and 15 mA, and scan-speed of 04.00 º/min. Electron microscopy was done on Zeiss SEM DSM 960A and Atomic Force Microscopy on a Nanoscope IV unit. The Varian CARRY 500 UV-Vis-NIR Spectrophotometer was used fot UV-Vis spectroscopy.

3. Results and Discussion

Fourier Transform Infra-Red spectroscopy:

Two milligram of ZnO NPs was mixed with 200 mg of potassium bromide (FTIR grade) and pressed into a pellet. The sample pellet was placed into the sample holder and FTIR spectra were recorded in FTIR spectroscopy. To validate again the nature of the synthesized nanoparticles and their purity Fourier Transform Infrared spectroscopy (FTIR) (Jasgo) studies were performed. A reports the typical FTIR spectrum of the pressed powder in the spectral range of 200-4000 cm^{-1}. The IR transmission is plotted so to single out the major absorptions observed at lower wave numbers.

The bands of biosynthesized zinc nanoparticles from plant extract of *Azadirachtaindica* were noticed at 3450.03, 1566.88, 1416.46,1384.64 and 513 cm^{-1} in the FTIR spectrum fig.2 (b), Whereas, bands of plant extract in fig.2 (a) were noticed at 3715-3930, 3460.63, 2982.37, 2426.37,2426.01, 2342.12, 1787.69, 1632.45, 1566.88, 835.99 to 1199.51, 647.95 cm^{-1}. In fig.2(a)the intense broad band at can be assigned to O-H ,N-$H_2$and C = O stretching band. The band in fig.2(a)of plant extract shifted to 3450.03, 1566.88, 1416.46 ,1384.64 and 513 cm^{-1} shows in Fig.2 (b).The absorption band corresponding to 3450.03 cm^{-1} was due to C-H, stretching vibrations of carboxylic acid and hydroxyl

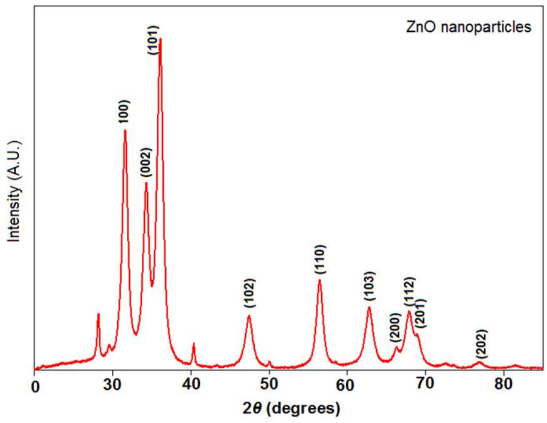


Figure 3. XRD Spectra of ZnO NPs synthesized by from 4.0 mM $ZnNO_3$.

stretch vibrations. Further, at 1019 cm^{-1}, which are sharper and broader for ZnO NPs participates in the reaction. In Fig.2 (b), IR spectra peak shows the bulk ZnO showing a high intensity broad band around 513 cm^{-1} due to the stretching mode of the zinc and oxygen bond. The significant changes in intensity peak due to reduction of Zinc Nitrate to ZnO NPs.

X-ray diffraction analysis of ZnO nanopowder:

The X-ray diffraction (XRD) pattern of the ZnO NPs prepared by bio-reduction is shown in figure 3. Strong peaks in the XRD profile indicate crystalline nature of the synthesized NPs. Prominent diffraction peaks around 31º, 34º, 36º, 47º, 56º, 62º, 66º, 67º and 68º of 2θ, which corresponds to reflections from (100), (002), (101), (102), (110), (103), (200), (112) and (201) crystal planes, were found to match with the JCPDS file 00-079-0206 ($a = b$ = 3.249 Å, c = 5.206 Å) for the hexagonal wurtzite structure of ZnO. Furthermore, the average crystalline size was calculated using Debye–Scherrer equation $d = k\lambda/(\beta\cos\theta)$, where d is the mean crystalline size of the powder, λ is the wavelength of Cu-K_α (λ = 1.54178 Å), β is the full width at half maximum (FWHM) intensity of the peak

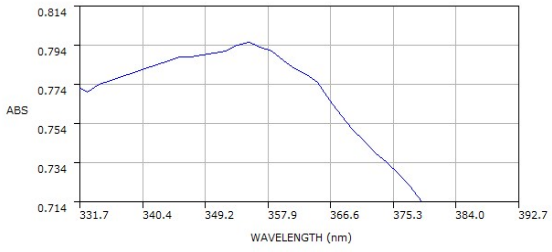


Figure 4. UV-Vis absorption spectra of ZnO NPs with a peak around 350 nm.

in radian, θ the Bragg's diffraction angle and k is dimensionless shape factor (a constant normally taken ~0.9). The average crystallite size of samples was determined to be about 18 nm. Diffraction peaks corresponding to the impurity were not found in the XRD confirming the high purity of the synthesized products.

UV-Vis spectroscopy:

UV-Vis spectroscopy showed a decrease in intensity of the characteristic surface plasmon band in the spectrum for the ZnO NPs, in the range 358-372 nm. As mentioned earlier, the solution turned yellow to yellowish brown indicating the formation of ZnO NPs (Fig.1). UV-vis spectroscopy also showed a broad absorption band centered around 230 nm and a small but sharp peak at 352 nm (Fig.4) corresponding to spherical ZnO nanostructure.

Microscopy results:

Figure 5 shows the SEM image of ZnO NPs. The SEM image was taken at 25,000x magnification. The image shows ZnO NPs are spherical in shape with smooth surface and the size of the particles around 16-36 nm.
Figure 6 shows size and shape of the nanoparticles which obtained directly from tip-corrected AFM measurements, and the shape of the nanoparticles is estimated on the basis of AFM images and line scans. The tip-corrected measured the size of ZnO NPs to be 20-30 nm and spherical in shape.

Anti-microbial activity:

Antimicrobial activity (figure 7) was analyzed using ZnO NPs in rayon pulp. The rayon fabric showed no antibacterial activity against both Gram positive and Gram negative bacteria. The results show the excellent antibacterial activity of the ZnO NPs in Rayon pulp samples which was found to be improving with increase in concentration of ZnO NPs. Antibacterial activity against *S. aureus* was maximum whereas that against *E. coli* was minimum. Further increase in concentration of ZnO NPs show appreciable increase in antibacterial properties against *E. coli* and the optimum concentration for antibacterial property was taken as 0.4 M. In case of ZnO NPs rayon pulp, the unwashed sample showed Maximum antibacterial activity.

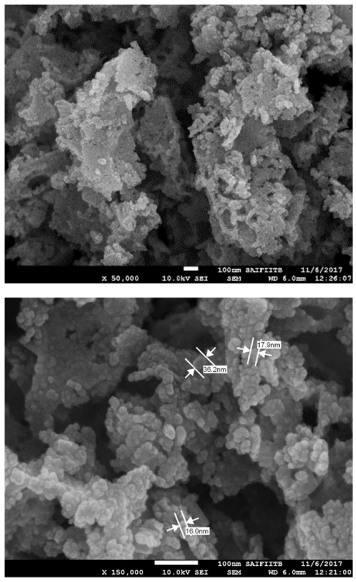


Figure 5. SEM images of ZnO NPs.

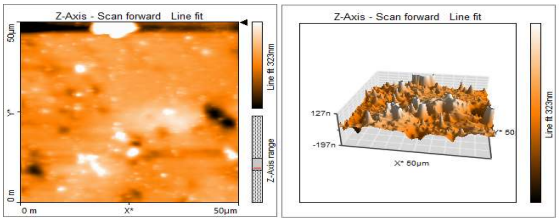


Figure 6. AFM images of ZnO NPs.

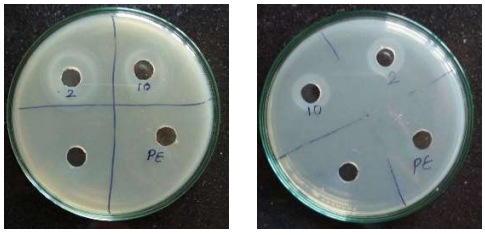


Figure 7. Antimicrobial activity of ZnO NPs with Rayon pulp against *S. aureus* (Left) and *E. coli* (Right).

4. Conclusions

Several approaches have been employed to obtain a better synthesis of ZnO NPs, such as chemical and biological methods. Development of easy, reliable and eco-friendly methods helps increase interest in the synthesis. Recently, synthesis of ZnO NPs using plant extracts has attracted attention of many materials scientists. We have presented a report on rapid biological synthesis of ZnO NPs using plant extract, which provides an environmental friendly, simple and efficient route for synthesis of NPs. The ZnO NPs were obtained through a homogeneous phase reaction between zinc nitrate and plant extract solution having various concentrations with pH 5 under constant sonication time and temperature. FTIR showed a peak around 513 cm^{-1}, which is characteristic absorption of zinc oxide bond. This confirmed the formation of zinc oxide nanoparticles. X-ray diffraction further confirmed the formation of a hexagonal wurtzite phase structure of ZnO, which is the most stable form at

ambient conditions. The average crystalline sizes estimated using the Debye–Scherrer equation was about 16 nm. Particle size measured from AFM was around 20 - 36 nm for the mostly spherical NPs. SEM image also showed that most of the NPs are spherical in shape formed within a diameter range of 10 - 40 nm. Finally, the antibacterial activity of the ZnO NPs in Rayon pulp samples was tested and was found to be improving with increase in concentration of the NPs.

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Modelling of Thermal Expansion Coefficient and Specific Heat of Nanomaterials

M. Singh

Department of Physics & Electronics, National University of Lesotho, Roma 180, Lesotho

Corresponding author: Phone: (+266) 5221 3531; E-mail: m.singh@nul.ls

Abstract: The size effect is fuelled by increasing the fraction of the surface atoms with lower coordination numbers, consequently increasing number of dangling bonds, which results in effecting the thermodynamical properties as cohesive energy, melting point and specific heat at nanoscale. The cohesive energy of nanoparticles decreases due to the dangling chemical bonds. On considering the surface effect, a simple model is discussed to study the size and shape dependence physical properties of nanomaterials. A simple model is discussed to study the size dependence of thermal expansion coefficient and specific heat of Ag and Ni nano sized solids with different shapes. Here, a shape factor is introduced, which is defined by ratio of surface area of non-spherical nanosolid to the surface area of nanosphere. It is predicted that the thermal expansion increases with decrease in particle size. It is realized that the particle shape can influence the thermal expansion of nanoparticles and this effect on the thermal expansion becomes larger with decreasing of particle size. On the same ground, I extended this model to analyse the specific heat of the nanomaterials. It is reported that our specific heat increases as particle size decreases. Our theoretical predictions agree fairly well with the available experimental and simulation results for nanosized particles in different shapes.

Keywords: Nanosphere, Particle shape, Nanofilm, Nanosolid, Nano materials

1. Introduction

Nanostructure science and technology is one of the broad and multidisciplinary fields of research in material science. Nanostructured materials comprise atomic clusters, threadlike structures, layered films and bulk nanocrystalline materials. Physics of nanomaterials is unlike from its macroscopic material and their properties are usually notable due to which nanomaterials are of vigorous research importance. Using different approaches of blend, it is possible to tune their thermodynamic properties. The thermodynamic properties are induced with the change of size as well as shape [1-2]. The cohesive energy is basic physical measure to define the strength of bond [3]. It is constant for bulk materials. But, for nanomaterials their cohesive energy depends upon on the size of the nanomaterials, which has been showed by experiments and also explained by different theories such as liquid drop model [4], surface area difference model and bond energy model. The vital idea is that the atomic cohesive energy controls the thermodynamic properties with the atomic coordination nature. The bond theory model describes how the surface dangling bonds changes the properties of nanoscale materials [5]. The thermodynamic properties of silver nanoparticles are reviewed like melting temperature, molar heat of fusion, molar entropy of fusion and temperature dependence of entropy and specific heat [6]. The findings reveal that these thermodynamic properties can be divided into two parts such as bulk quantity and surface quantity; also surface atoms dominate for the size effect on the thermodynamic properties of nanomaterials. The heat capacity of ideal nickel, copper, gold, aluminum and palladium fcc clusters with diameter up to 6 nm has been studied in terms of the molecular dynamics theory using a tight binding potential [7].

Thus, an analytical study of the literature reveals that a lot of experimental work has been done allied to the size dependence of thermal expansion and specific heat. Although, the theoretical works are lacking. Some efforts, based on potential approach and simulation made by earlier workers, are grounded on several approximations which involve tedious computations and are time overwhelming. It is a very tough task to extend the potential based approach for complicated solids. In the present work, I used the bond energy model [8] and reported a very simple and authentic method to study the effect of size and shape on thermal expansion coefficient and specific heat of nanomaterials.

Table 1. Input data used in calculations

Shape of cross section	Spherical	Film	Regular tetrahedral	Regular hexagonal
Shape factor	1	1.15	1.49	1.24

2. Materials and Methods

Bond energy is the measure of bond strength. The sum of bond energies of all the atoms is expressed as the cohesive energy of metallic nanoparticles. The cohesive energy of a solid is defined as the energy required in breaking the atoms of the solids into isolated atoms. Since half of the total bonds of each surface atom are dangling bonds, according to the bond energy model, the cohesive energy of nanoparticles is the summation of contribution of inner shell and outer shell atoms, which are defined as $E_{cn} = E_{cb}\{1-(\gamma N/n)\}$ [8]. Where n and N are the total number of atoms and surface atoms of nanosolids respectively. Here, γ is the relaxation factor, which is defined as the ratio between the dangling bonds and the total bond of the atoms. Agreeing that the number of bonds is proportional to the surface area, one can write $\gamma = S'/S$. Here, S' is the surface area with dangling bonds and S is the entire surface area of the atom. In the low dimension of nanosolids, the different position of atoms are discussed [5] and reported the value of γ may have the following 0, ¼, ½, 3/4 and 1. Thus, the relaxation factor is in the range of $0 \le \gamma \le 1$. The value of *N/n* can be calculated using the concept of surface area to volume ratio as $N/n = 4\eta d/D$. Where, η is the dimensionless shape factor which is defined by the ratio of nanoparticle in any shape whose volume is the same as spherical nano particle to the area of spherical nanoparticle. Here, *d* is the diameter of nanoparticle. It is reported that the cohesive energy has a linear relation with the melting temperature of the solids [9]. Therefore, the size and shape dependent melting temperature of nanomaterials should follow the similar relation given as

$$T_{mn} = T_{mb}\{1-(\gamma 4\eta d/D)\} \quad (1)$$

It is listed [10] that the size and shape dependent thermal expansion coefficient of nanomaterials as $\alpha_{mn}/\alpha_{mb} = T_{mb}/T_{mn}$. Consequently, from equation (1) one can get the thermal expansion coefficient of nanomaterials as

$$\alpha_{mn} = \alpha_{mb}\left(1-\gamma\frac{4\eta d}{D}\right)^{-1} \quad (2)$$

Where, α_{mb} is the thermal expansion coefficient of corresponding bulk materials. Xiong et al. [11] disclosed that specific heat increases as the particle size decreases. The increased specific heat is caused by the atomic thermal vibrational energy of the surface atoms. On this ground, theory is extended to study the specific heat of nanomaterials in different sizes and shapes. It is presented the specific heat of nanomaterials as

$$C_n = C_b\frac{1}{1-\gamma\frac{N}{n}} \quad (3)$$

3. Results and Discussion

The input parameters [11-12] required for the present work are given in Table 1-2. Variation of thermal expansion coefficient and specific heat of Ag and Ni nanomaterials has been calculated by eq. (2) and (3) respectively. In this work, nanosolids are selected in four different cross sectional shapes like spherical, film, regular hexagonal and regular tetradedral. The graphical representations of the calculated results of thermal expansion coefficient are shown in figs. (1 and 2). It is observed that the thermal expansion coefficient increases on increasing the size of the nanoparticles, which indicates that the strength of metallic bond of nanomaterialds is weaker than that of bulk metal. It is reported that the thermal expansion coefficient is maximum for regular tetragonal shape and minimum for spherical shape. This behaviour can be clarified on the origins of the bond energy model of cohesive

Table 2. Input data used for calculations [11, 12]

Nanomaterials	*d*(nm)	α_{mb} ($10^{-5}/K$)	C_b (*J*/Mol/*K*)
Ag	0.319	1.8	25.35
Ni	0.249	3.3	26.07

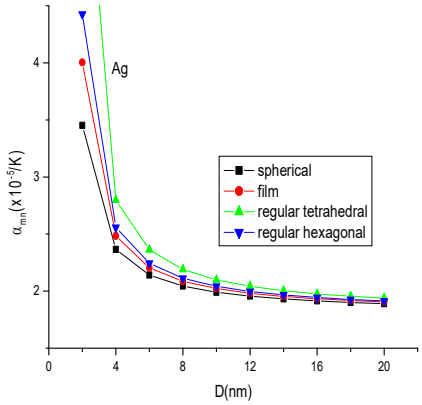

Figure 1. Particle size dependent thermal expansion coefficient of Ag nanosolid in spherical, film, tetrahedral and hexagonal shapes.

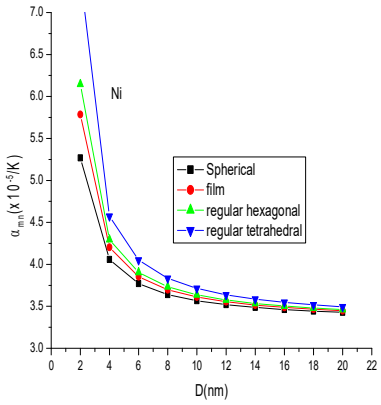

Figure 2. Particle size dependent thermal expansion coefficient of Ni nanosolid in spherical, film, tetrahedral and hexagonal shapes.

energy, which differs with shape and size of nanomaterials. As the particle size reduces, surface to volume ratio of the nanomaterials rises. Thus, the number of dangling bonds increases and consequently cohesive energy decreased. The model is extended to study the specific heat of Ag and Ni nanomaterials. Using equation (3), the size and shape dependence specific heat is calculated of Ag and Ni nanomaterials. The computed values of specific heat of Ag and Ni nanosolids are shown in figs. (3-4) along with available experimental data [12]. It is observed that the specific heat increases with decrease in particle size. To account for the shape of the cross section, shape factor is incorporated and it is clearly confirmed by this study that thermodynamical properties are not only a size dependent but also depends on the shape. There is a good agreement between the model and the available experimental findings, which validates the fitness of the model suggested for specific heat. The increased nature of specific heat can be explained on the basis of the electron and phonon contribution to specific heat. In nanostructure, phonons usually dominate and the phonon properties of the structure become a particular importance for specific heat. Since, phonon-phonon interaction increases with reduction due to the confinement, which causes the increase of thermal resistance and decrease of thermal conductivity, consequently increases the specific heat. In this theory, the shape factor is used to explain the shape effects of the nanosolids; though, the different influences of the edge, corner, and the face atoms to the cohesive energy are not taken in account.

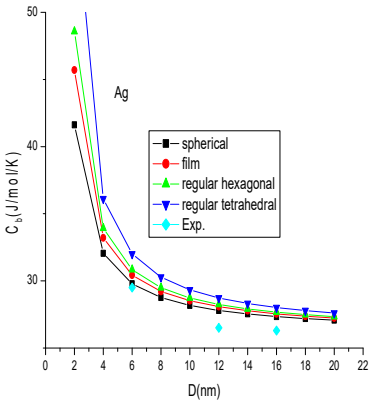

Figure 3. Particle size dependent specific heat of Ag nanosolid in spherical, film, tetrahedral and hexagonal shapes. Exp. data [12] shown by points ♦.

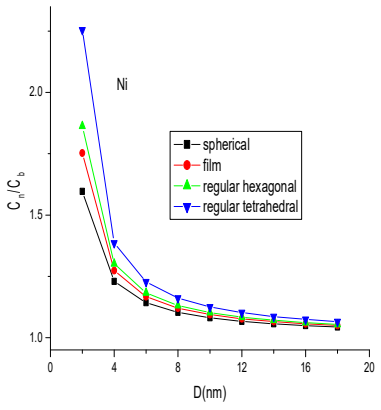

Figure 4. Particle size dependent specific heat of Ni nanosolid in spherical, film, tetrahedral and hexagonal shapes.

4. Conclusions

In the present work, I have discussed the simple and straight forward theory based on bond energy model, free from approximation to calculate the thermal expansion and the specific heat of Ag and Ni nanomaterials in different shapes and sizes. It is reported that the thermal expansion and specific heat increases with decrease in size. Additionally, it is also reported that the thermal expansion and specific heat also changes with the shape of the nanomaterials and its value is larger for regular tetragonal and minimum for spherical shape. Results reported are compared with the available experimental data and shown that findings are reasonable consistent with the corresponding experimental values.

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