Radioactive Waste Management and Analysis for Nuclear Power Plants

UMAIR ALI 18016522-008
HAMMAD YOUNAS 18016522-001

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Abstract

Nuclear Waste management is current and challenging research topic. Nuclear power plants generate electricity with the help of radioactive material which burns and produces steam to drive turbine. In this paper calculations are made to predict the estimated waste of nuclear power plants. Some precautions and techniques are reviewed which are used to manage nuclear waste. This paper will help to understand current status of nuclear waste quantity of production as well as it will describe the techniques from waste generation to waste disposal.

1 Introduction

When we think about nuclear energy the word 'atom bomb' flashes in our mind and we consider it dangerous because it has intense energy to size ratio. Nuclear energy has a peaceful use in hospitals, industries, labs, chemicals and specially electricity generating power plants. With the increase in demand of electricity all available resources are applying to overcome the need. According to world energy association 10.4% of the total electricity is producing by the Nuclear energy which is more than combination of Oil, solar, wind, geothermal and tidal energy resources. There are thirteen countries which are producing their one fourth of electricity from the Nuclear Energy(Rising, 2019). In (IAEA, 2016) European nuclear society mentioned that in 31 countries 450 nuclear power plants with an installed electric net capacity of about 392 Giga Watts(GW) are in operation and 60 power plants with capacity of 60 GW are in 16 countries under construction.

Above statistics represent the importance but still use of nuclear energy is controversial not only because of its long term effects during operation but it also produces huge amount of radiations

even when it becomes useless. Radioactive waste has highly hazardous effects on human being, animals, plants, crops and environment furthermore Radioactive wastes if not properly dispose, can cause cancer, haemorrhage, birth defects and contaminate both water and environment(Ali, Iqbal and Awan, 2015)

Despite decades of effort, the nuclear industry does not yet have a working solution for managing spent fuel and high level waste, the most radioactive products generated by nuclear power plants(Ramana, 2018). Nuclear waste management is current issue which is challenging topic for researchers.

2 Literature review

A German chemist named as Martin Klaproth in 1789 discovered the radioactive substance uranium. With the passage of time more nuclear substances introduced to world like barium which contained same energy but it was half in size. From mid of nineties projects started to generate Electricity from the nuclear energy which arose the problem of nuclear waste generation.
The last few years have seen some significant changes in the financing of large infrastructure projects, including nuclear power plants(Terlikowski et al., 2019). Disposal of radioactive waste since the nuclear energy commercial use is hot research topic. Nuclear waste has emerged as a very salient issue in the nuclear power debate(Sjöberg and Drottz-Sjöberg, 2009). This is because of lack of understanding about the nuclear waste hazards. Rapid expansion of nuclear technologies and nuclear energy for power generation in emerging (developing) countries necessitate undertaking urgent skills development programs(Alam, Sarkar and Chowdhury, 2019) but still dealing with a nuclear waste can be very harmful.

(sir need your suggestions specially where should we converge...)

3 Estimation of waste generating worldwide

Before solution there is need to understand the problem that is the reason for our first concern which is collection of approximate Nuclear waste production data of the world. For this there is need to search the countries which deal with the nuclear energy. Nuclear power efficiently boils the water and turns it into steam. This steam in turbine helps to generate electricity. If we find the mass of decayed nuclear substance for producing 1MW of electricity then we can estimate the total waste of countries. According to european nuclear society 1kg of uranium-235 produces around 24,000,000

KWh of energy(ENS, 2019) which is equal to 24 GWh approximately.

Table 1: country wise Estimated waste production of Nuclear Power plants

Country	**Power Plants**	**Estimated Output (MW)**	**Estimated nuclear Waste production (Kg)**	**Estimated waste Per Year (kg/Year)**
Argentina	3	1.657	19.05 x 10^{-9}	0.6009
Armenia	1	0.375	4.31 x 10^{-9}	0.1359
Belarus	2	2.218	25.51 x 10^{-9}	0.8043
Belgium	7	5.913	67.99 x 10^{-9}	2.1441
Brazil	3	3.129	35.98 x 10^{-9}	1.1347
Bulgaria	2	1.926	22.14 x 10^{-9}	0.6982
Canada	19	13.524	155.26 x 10^{-9}	4.9046
China	56	51.902	596.87 x 10^{-9}	18.8229
Czech Republic	6	3.930	45.19 x 10^{-9}	1.4252
Finland	5	4.352	50.04 x 10^{-9}	1.5783
France	59	64.760	774.74 x 10^{-9}	23.4861
Germany	8	10.799	124.18 x 10^{-9}	3.9161
Hungary	4	1.889	21.72 x 10^{-9}	0.6849
India	27	9.215	105.97 x 10^{-9}	3.3418
Iran	1	0.915	10.52 x 10^{-9}	0.3318
Japan	45	42.940	492.81 x 10^{-9}	15.5727
Korea, Republic	28	27.153	312.25 x 10^{-9}	9.8471
Mexico	2	1.440	16.56 x 10^{-9}	0.5222
Netherlands	1	0.482	5.54 x 10^{-9}	0.1748
Pakistan	7	3.348	38.50 x 10^{-9}	1.2142
Romania	2	1.300	14.95 x 10^{-9}	0.4715
Russian Federation	43	32.02	368.28 x 10^{-9}	11.6141
Slovakian Republic	6	2.694	30.98 x 10^{-9}	0.9770
Slovenia	1	0.668	7.68 x 10^{-9}	0.2422
South Africa	2	1.860	21.39 x 10^{-9}	0.6745
Spain	7	7.121	81.89 x 10^{-9}	2.5835
Sweden	10	9.651	110.98 x 10^{-9}	3.5000
Switzerland	5	3.333	38.32 x 10^{-9}	1.2087
Taiwan, China	8	7.652	87.99 x 10^{-9}	2.7751
Ukraine	17	14.007	161.08 x 10^{-9}	5.0798
United Arab Emirates	4	5.38	61.939 x 10^{-9}	1.9533
United Kingdom	15	8.918	102.55 x 10^{-9}	3.2342
USA	103	103.336	1188.36 x 10^{-9}	37.4762
Total	510	451.832	5196.06 x 10^{-9}	163.8632

Source: Nuclear power plants world-wide, in operation and under construction, IAEA as of 27 November 2016.

From this estimation we further can estimate the 1MWh is generated by burning 4.1x10^{-5} kg of nuclear substance. So just 4.1x10^{-5} of nuclear substance gives 1MW for an hour. we can conclude 11.5 x 10^{-9} kg produces 1MW of energy.

Table 1 shows the approximation of waste produced for each country with capacity of output in mega watt and number of power plants which are in operation or under construction. Calculations

are performed below

$$\text{1kg produces} = \text{24,000MWh of energy}$$
$$\text{As 1MWh} = \text{(1MW/3600sec)}$$
$$\text{1kg produces} = \text{(24,000x3600)MW=86,400,000MW}$$
$$\text{1MW plant waste} = \text{(1kg / 86,400,000)} = 11.5 \text{ x } 10^{-9} \text{ kg}$$

Above data explain the amount of nuclear waste which is producing on yearly basis.We can further estimate the waste that will produced in future. Then a question arises in mind Where this waste goes and how we are dealing it. In figure 1 the bars are showing the per year waste production of

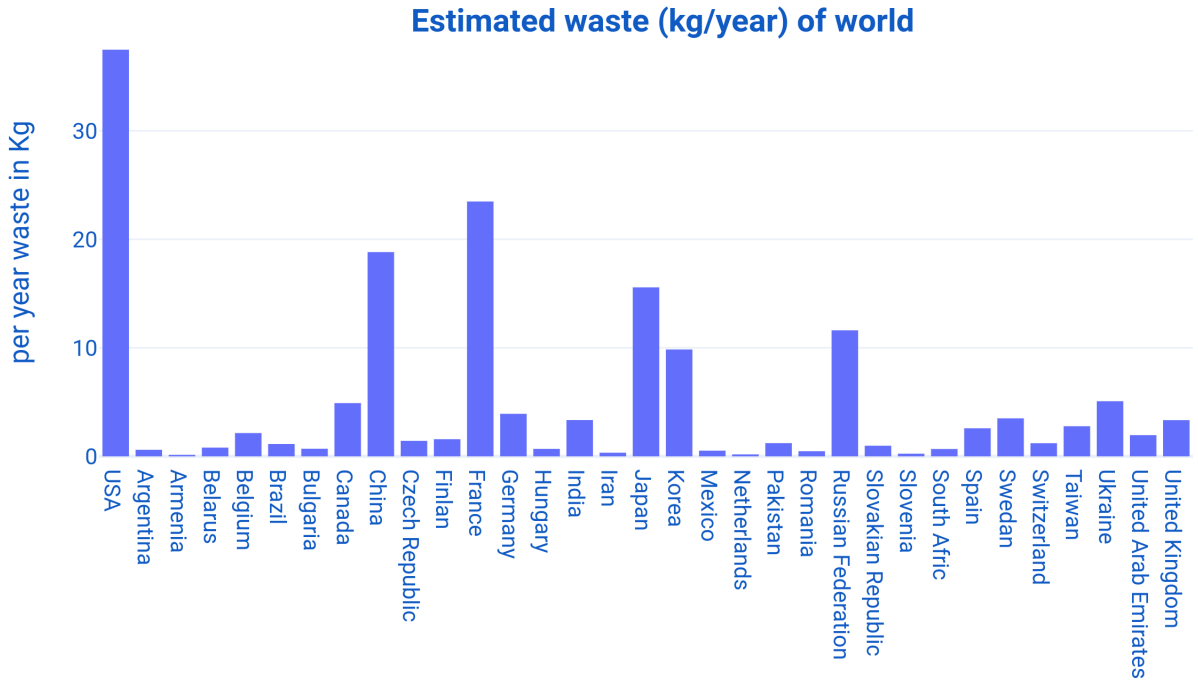

Figure 1: per year nuclear waste production

the countries. Figure 2 shows the percentage of the country.

4 Managing Nuclear waste

After the decay of nuclear substance it still produces radiation which are hazardous even killing.Over the years, some scientists have supported the view that low levels of radiation are not harmful, while other scientists have held that all radiation is harmful(Perrow, 2013). Collectively we support the

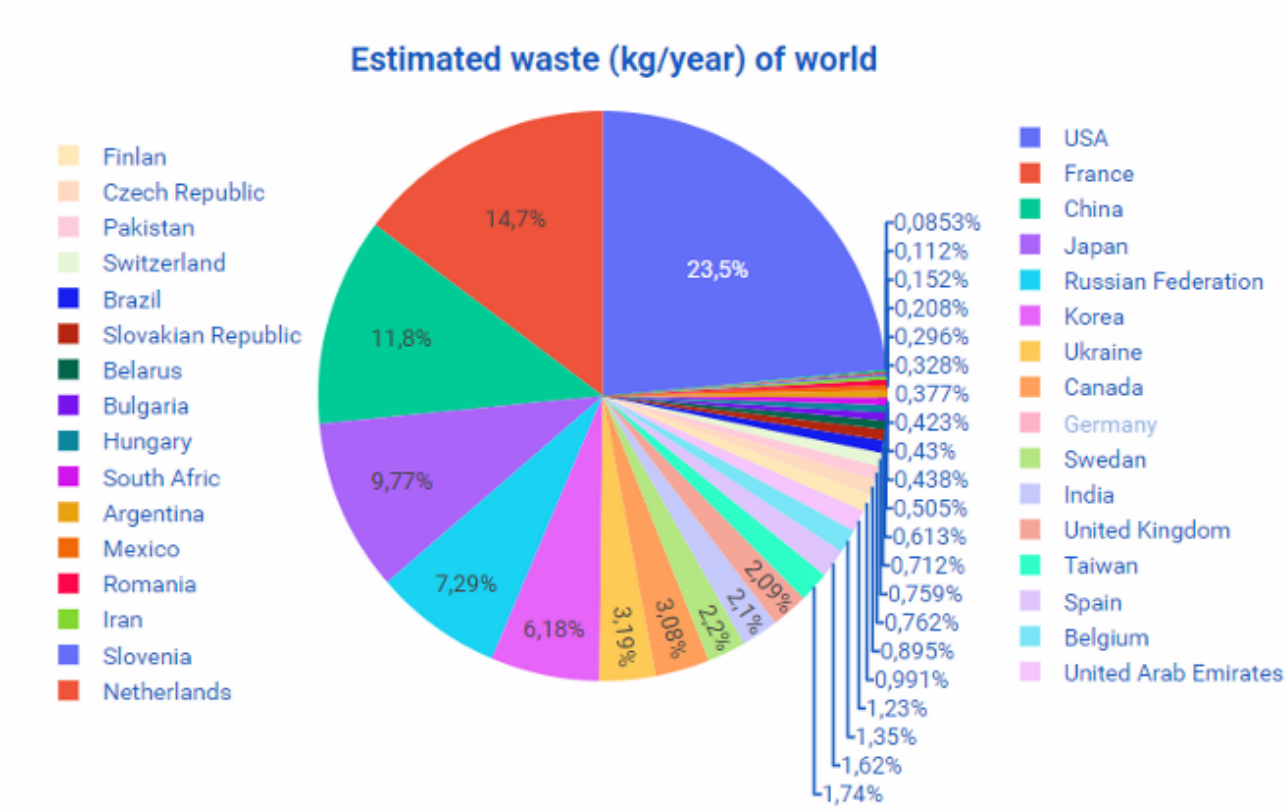

Figure 2: Nuclear waste production percentage per country

idea that all radiations are harmful from low level harm to high level harm. To protect ourselves from these radiations different techniques or technologies are used.

We have two main options to get rid of nuclear waste first is to dispose the nuclear waste into ground and second is to send it into space. Sending nuclear waste into space is a permanent solution but it is very expensive method so we have to choose another ways which are safe and economical to dispose waste into earth or in protective walls of different chemical materials. we can not dispose nuclear waste on daily basis. The main alternatives involve temporary above-ground storage at a centralized facility or next to nuclear power plants(Keeney and von Winterfeldt, 1994). To deal with nuclear waste there are limitations for human but not for robots. We can control robots to deal with nuclear waste.

After some amount of collection we can dispose the waste into ground. To transport the nuclear waste into designated place also contains so many risks. It is highly recommended that population remain away from nuclear waste even during transportation of nuclear waste. Proposals to transport nuclear waste have generated concerns about potential harm to the health and economic well-being of those who live near the route (Gawande and Jenkins-Smith, 2001). This indicates the sensitivity

of dealing with nuclear waste. Instead of inventing completely safe technique which is a dream for now it is better approach to stand on shoulder of giants.

By reviewing the last work on nuclear waste management we would be able to contribute something for improvements till the effective solution. For handling of radioactive waste under consideration methods are concentrate-and-contain, dilute-and-disperse, delay-and-decay, Radioactive waste vitrification, near surface disposal, deep geological disposal and partitioning and transmutation.
(sir need your suggestions to proceed further)

5 Conclusion

one kilogram of uranium-235 contains same energy as we obtain by burning 3 million kilogram of coal. The countries which are developed like USA, China, Japan, Russia, France and korea use massively nuclear material to generate electricity. Dealing with nuclear waste required professional and technical skills. It not only harms workers but also the population even during its transportation.Best available precautionary measurements need to be consider but still there is need to find the stable technique which would not only reduce its harm but also will stop its radiation from penetrating.

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Appendix

Statutory Declaration

I hereby declare that the paper presented is my own work and that I have not called upon the help of a third party. In addition, I affirm that neither I nor anybody else has submitted this paper or parts of it to obtain credits elsewhere before. I have clearly marked and acknowledged all quotations or references that have been taken from the works of others. All secondary literature and other sources are marked and listed in the bibliography. The same applies to all charts, diagrams and illustrations as well as to all Internet resources. Moreover, I consent to my paper being electronically stored and sent anonymously in order to be checked for plagiarism. I am aware that the paper cannot be evaluated and may be graded "failed" ("nicht ausreichend") if the declaration is not made.

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