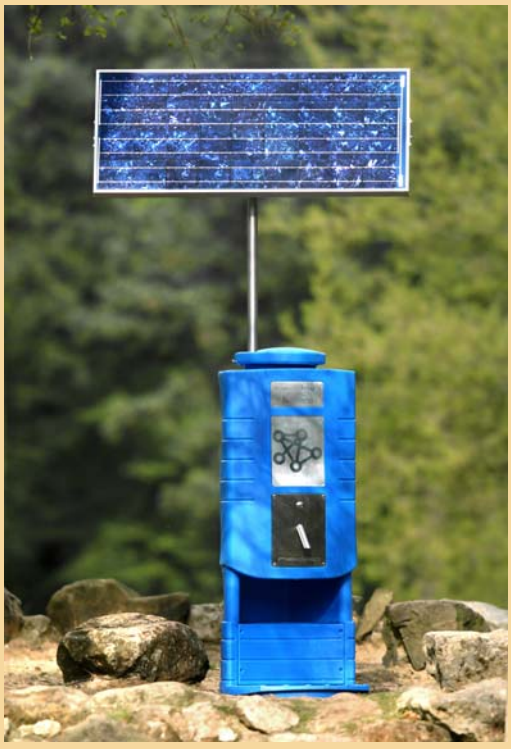
kiwa
Partner for progress

Kiwa Evaluation Report 05.001
January 2005

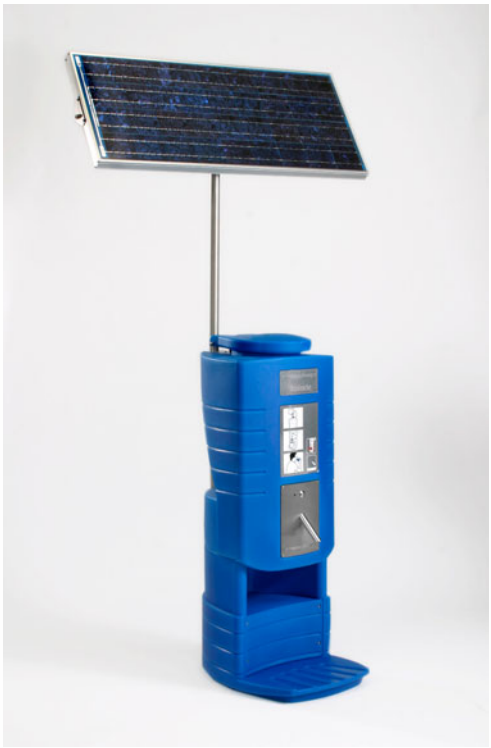
Declaration of Performance of the Naïade Water Purification System



Kiwa Evaluation Report
05.001
January 2005
Unique evaluation

Declaration of Performance

Cliënt	Nederlandse Apparatenfabriek "Nedap", Parallelweg 2 K, 7140 AC GROENLO, Netherlands, P.O.Box 101, 7140 AC GROENLO. Chamber of Commerce number 08013836
Product	SOLAR WATER PURIFICATION NAIADE, Nedap product code: 9889078



Based on evaluations of performance by Kiwa, the product referred to in this declaration manufactured by Nedap Power Supplies, may, on delivery, be relied in accordance with the conclusions and limitations demonstrated by Kiwa for the improvement of the microbiological safety of drinking water in situations where no safe drinking water is available.

Kiwa NV
Certification

Director

Kiwa N.V.
Certification

This declaration consists of 25 pages. Publication is allowed.

Colophon

Title

Declaration of performance

Naïade Water Purification System

Project number
11.3992.001

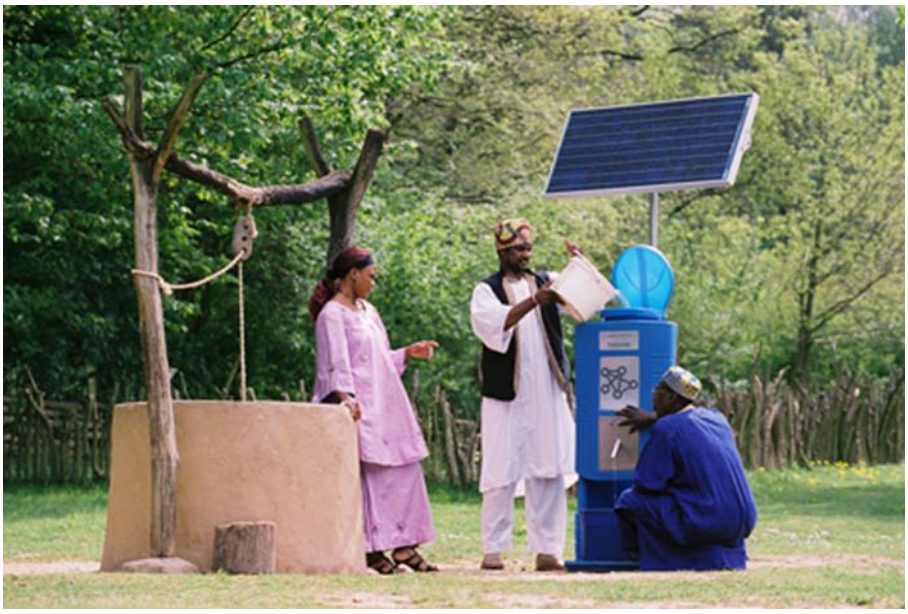
Project manager
H. van der Jagt

Quality Assurance
L.J. van Driel, B.Cornelius, G.J. Medema, H. Volkers,
P. Wessels

Author(s)
H. van der Jagt

Abstract

The Naïade Water purification system is a solar-powered water treatment system. Filters first remove particles, turbidity, algae, helminth eggs and large protozoan from the water. The filtered water is then exposed to ultraviolet light to inactivate protozoa, bacteria and viruses. The Naïade operates independently without being connected to an electricity supply or water mains. Naïade makes use of solar energy to clean and disinfect water, without the use of chemicals.



The available data on the disinfection efficacy of this system were evaluated. Four studies in different countries have been performed under normal quality control circumstances and relevant protocols. All these studies used raw surface water from the field, representing conditions in which the equipment will be used in practice. The studies do represent a range of water types, but not all possible conditions that can be experienced in rural areas.
The studies used the same parameters: turbidity, coliforms at 37 °C and 44 °C, *E. coli* and heterotrophic plate counts and these were analysed in accordance with international standards. In some cases spiking of the influent samples with additional cultivated bacteria or domestic wastewater was performed.
The tests show that the Naïade system is adequate for its application: to purify polluted raw water by filtration and inactivate *E. coli* by 1.7 logs. Care should be taken to avoid fouling of the system (esp. the UV lamp) and the use of raw water that has a high level of fine particles or compounds that absorb UV, since this may compromise the disinfection efficacy.

The tests show that the water quality of the effluent does not fulfil the microbiological guidelines for drinking water from the World Health Organisation Guidelines for Drinking Water Quality or the European Drinking Water Directive (DWD) under all raw water conditions. The efficacy of the system is sufficient in special conditions, such as disasters that have compromised the delivery of safe drinking water or in rural settings or other situations where no source of safe drinking water is available. The system can produce water that meets the drinking water guidelines in situations with relatively clean raw waters.

Contents

Acknowledgements

Regarding this declaration of performance, Kiwa is responsible for the parts related to the verification of the equipment, data collection and analysis, test data management, data interpretation and the preparation of this report.

Kiwa N.V.
Sir Winston Churchill-laan 273
P.O. Box 70
2280 AB Rijswijk
The Netherlands
Office Tel. (++31) 70 4144 00
Fax (++31) 70 4144 50
Internet www.kiwa.nl

Microbiological research has been performed by:

IHE
UNESCO-IHE Institute for Water Education
Westvest 7
2611 AX Delft
The Netherlands

Microbiological analytical study has been performed by:

Marmara University Faculty of Engineering
Environmental Engineering Dept.
34722 Göztepe / İstanbul
Office Tel.: +90 - 216 - 348 02 93 / 267
Fax : +90 - 216 - 348 13 69
E-Mail : kerc@eng.marmara.edu.tr

Additional microbiological analytical study has been performed by:

Ministry of Water and Livestock Development,
Water Quality Laboratories Unit,
P.O. Box 35066, Day-es-Salaam
Tanzania, Africa
Office Tel. + 225 22 2450047
Fax. + 255 22 2451447

Additional microbiological analytical work has been performed by:

VITENS N.V.
Boogschutterstraat 29a
7324 AE Apeldoorn
The Netherlands

Tel. +31 26 3600111
Fax. +31 25 3648444

The manufacturer of the equipment is:

Nedap Power Supplies N.V.
Parallelweg 2K
P.O. Box 101
7140 AC Groenlo
Office Tel. +31 544471823
Fax. +31 544466008
Internet. www.nedap.com

We wish to thank the participants in this study for their co-operation, especially Gertjan Medema of the Kiwa Microbiological Department.

1 Introduction

1.1 BACKGROUND

The disinfection efficacy of the Naïade Water Purification System supplied by Nedap Power Supplies has been carefully evaluated on the basis of objective performance information and analytical studies available.

1.2 APPLICATION AND USE

The system consists of solar panels, bag filters, a storage tank, a UV-reactor and polymeric lining. The Naïade Water Purification Unit is intended for domestic use.

Raw water

Ŷ

Filter Screen 25 µm

Ŷ

Filter Screen 10 µm

Ŷ

Water tank (capacity 100 litres)

Ŷ

UV disinfection lamp (16 watt)

Ŷ

Disinfected water

Figure 1: Scheme of Naïade UV-system

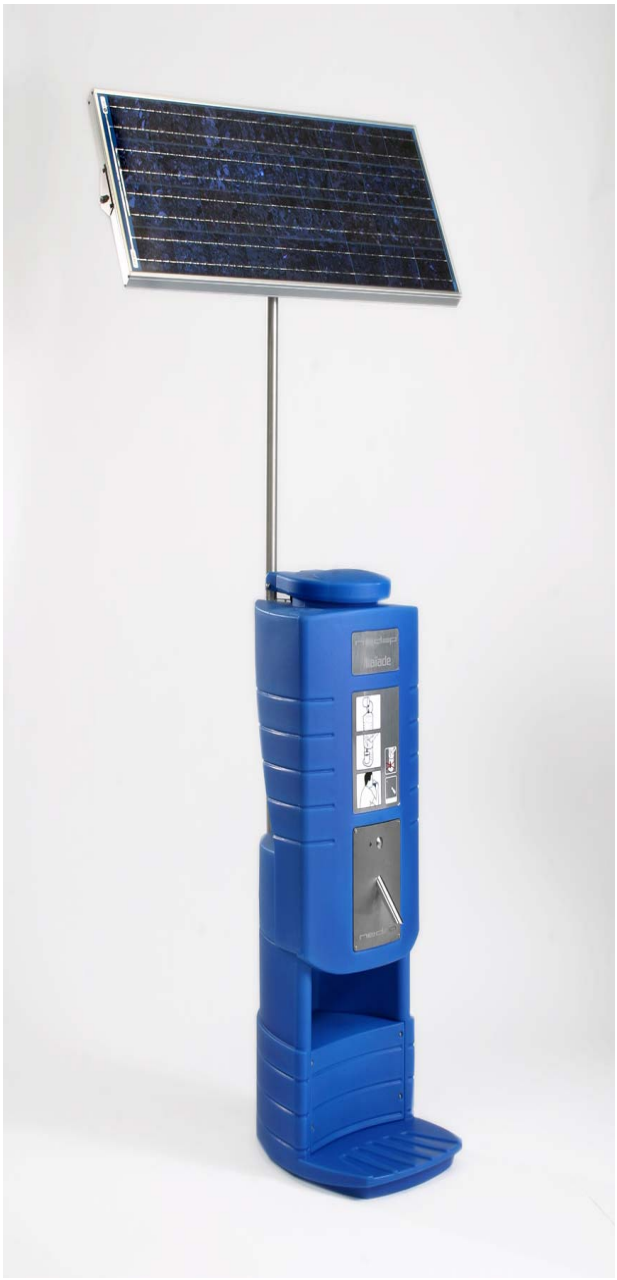


Figure 2: Naïade UV disinfection system

1.3 MARKING

The products are marked with the Nedap Power Supplies mark.

1.4 PLACE OF THE MARKING

- On the identification plate

1.5 COMPULSORY SPECIFICATIONS

- trade mark/type or logo
- construction
- material used

- type of connections
- year of manufacture
- primary part, inside filters working device
- secondary part, inside reservoir storage
- tertiary part, inside UV device
- description of the flow in double partition
- maximum primary water temperature
- intended purpose of use of the connection ends.

1.6 METHOD OF MARKING

- Non-erasable
- Visible after installation

1.7 RECOMMENDATIONS FOR CUSTOMERS

1.7.1 TIME OF DELIVERY

Check at the time of delivery whether**:**

- the delivery by the producer is in accordance with the agreement
- the mark and marking method are correct
- the products show no visible defects as a result of e.g. transport etc.
- the availability of instruction(s) for installations, use and maintenance

1.7.2 *CONTACT*

If you should reject a product on basis of the above please contact

- Nedap Power Supplies,
  Parallelweg 2K
  P.O. Box 101
  7140 AC Groenlo
  The Netherlands
  Telephone: +31 544 471823
  Fax: +31 544 466008
  Internet www.nedap.com

1.7.3 CONSULT

Consult the producer's processing guidelines and procedures for the proper storage, method(s) of transport, installation and application and maintenance of the products concerned. .

1.7.4 APPROVAL

This Declaration of Performance is exclusively related to the disinfection part of the SOLAR WATER PURIFICATION NAIADE, Nedap product code: 9889078, on the basis of the information provided by the trial-studies. Kiwa is not responsible for technical malfunctions or unsuitability for products that are delivered under this Declaration of Performance.

2 Technology description

2.1 PRODUCT SPECIFICATION

2.1.1 GENERAL

The Naïade Water Purification System consists of two bags filters at the inlet for filtration and a UV-reactor unit at the outlet for disinfection of the raw water. Both filters are applicable for filtering particulate matter, like insects & worm-eggs. The unit is powered by a solar panel. A battery feeds the system during dark periods. The reactor with UV-lamp will disinfect raw water by inactivating harmful micro-organisms from available water sources with UV-irradiation in order to deliver the final effluent.

2.1.2 ADDITIONAL SPECIFICATION FOR FILTERS

A coarse sieve removes twigs, leaves, gravel etc. A fine mesh cloth filter removes particulate matter down to 25µm. A very fine cloth filter removes worm-eggs, large cysts down to 10µm. These are selected bag filters because it is important that they can be cleaned easily.

2.1.3 ADDITIONAL SPECIFICATION FOR UV-C UNIT

After filtration the pre-treated water flows in a separate compartment (irradiation chamber). By pressing the button water flows past the UV-lamp in a specially designed reactor.
The 16W TUV UV-lamp emits UV-light at a wavelength of 253.7 nanometer. This light is not visible and is harmful to eyes and skin. UV-light is absorbed by micro-organisms and penetrates through the cell wall of the micro-organisms damaging their DNA. This causes inactivation rendering the micro-organisms incapable of growing and multiplying. Damaged DNA cannot be duplicated and this inactivates the micro-organisms. The 16 Watt UV-lamp delivers a minimum dose of 40 mJ/cm^2, which can provide generally approximately 4 logs (99.99%) inactivation of bacteria, protozoa and most viruses under laboratory conditions. The appropriate UV-lamp maintains a minimum of 80% transmittance at the end of the life time of the lamp.

2.2 PRODUCT PARTS DESCRIPTION

- Filter gauze Naïade, stainless steel 304
- Filter ring 10 micron Naïade, Nylon
- Filter ring 25 micron Naïade, Nylon; Polypropylene, Pouring material
- Reservoir Water Naïade, polyethylene (LMDPE)
- Reactor top part Naïade alu, aluminium anodized

- Reactor tube part Naïade alu, aluminium anodized
- Reactor bottom part Naïade alu, aluminium anodized
- Tube glass Naïade, Quartz glass
- Spring glass tube Naïade, stainless steel 304
- Spring water guiding Naïade reactor, stainless steel 304
- O-ring EPDM
- Housing electronics Naïade, ABS
- O-ring NBR
- Grommet valve reactor, brass
- O-ring EPDM
- Ring press Glass tube Naïade, brass
- Valve solenoid Naïade, brass/rubber
- Grommel valve Faucet, stainless steel 304
- Grommel Faucet, stainless steel 304
- UV-C irradiation lamp type TUV 16W 4P-SE

2.3 EVALUATION OF THE PRODUCT SPECIFICATIONS

The Naïade is a water purification system designed to inactivate microbiological contaminants. There is one UV low pressure lamp. The UV-lamp (type TUV 16W 4P-SE) emits most of its disinfecting energy at 253.7 nm wavelength. The system is a stand-alone system equipped with a sonar panel. This solar panel absorbs sunlight that is converted to energy in order to power the UV-lamp. In case electricity is available, it is possible to operate the Naïade without using the solar panel.

The product parts, including the UV lamp, are suitable for its application.

3 Evaluation of performance

The evaluation of the disinfection efficacy of the Naïade purification system is performed in the field. Independent investigations on the Naïade purification system has been performed by 4 institutes. These investigations are described in chapter 3.1, 3.2, 3.3 and 3.4. The studies have tested the log reduction value (LRV) for *E. coli*/coliforms or heterotrophic plate count bacteria. These testing activities are carried out by the Marmara University in Istanbul (Turkey), Water Quality Laboratories Unit in Tanzania and Unesco-IHE in Delft (The Netherlands). The laboratory of Water Supply Company Vitens in The Netherlands provided additional study results in order to obtain an indication of the performance of the system.

3.1 TEST REPORT MARMARA UNIVERSITY ISTANBUL

3.1.1 Introduction

The Naïade Purification system that is supplied by Nedap Power Supplies has been tested between July and September 2004 by the Marmara University Environmental Engineering Department in Istanbul. The provided test report describes the disinfection efficacy of the Naïade water purification system.

3.1.2 Principle

Omerli raw reservoir water has been used for this experiment. The composition of this raw water has been monitored by ISKI laboratories. The raw water samples contained a concentration of 500 to 7000 CFP/100ml coliform bacteria and 40 – 2000 CFP/100ml *E. coli*. The concentration of the water quality parameters is comparable with common raw surface water from other locations. The TOC concentration is high (16mg/l).

3.1.3 Experimental

Initial tests have been carried out with raw water obtained from the reservoirs. Each day the raw water has been passed through the filters to perform the filtration capacity. Additionally water has been analyzed after a stagnation time of 2-3 days in the storage tank. The disinfection capacity at UVT 254nm has been measured on raw water samples. Finally, some experiments were conducted with water samples spiked with domestic waste water in order to increase the initial bacteria concentrations.

3.1.4 Evaluation of the results of the experiments

The accuracy of the complete filtration system is limited due to clogging and the presence of algae in the incoming water.

Depending on the water quality the filters need to be cleaned after every 1000 liter discharge. The use of water containing algae at a high ambient temperature will increase the growth of micro-organisms and the biofilm forming potential in the filter chamber and the reservoir. Water quality parameters that influence UV-absorbance have been measured to evaluate the performance of this UV-system. By exceptions, due to a low concentration of bacteria in the influent, a removal of approximately 80% can be reached. The efficiency of the biological removal is influenced by highly concentrated faecal coliforms and faecal streptococcus in the influent.
According to the results of the experiments limitations of the disinfection properties are depending on the presence of algae, suspended matter smaller than 25 µm and possible extreme concentrations of the coliforms and faecal streptococcus in the influents.
The efficiency of the UV-lamp transmittance at 80% (by decreasing the normal capacity) is demonstrated by adding humic acid and high polluted waste to Omerh raw water. The inactivation of coliforms reached 83% under these circumstances.

3.2 TEST REPORT WATER QUALITY LABORATORIES UNIT, MINISTRY OF WATER AND LIVESTOCK DEVELOPMENT DAR ES SALAAM TANZANIA

3.2.1 Introduction

The Naïade Purification system that is supplied by Nedap Power Supplies has been tested in 2004 by the Water Quality Laboratories Unit from the Ministry of Water and Livestock Development at Dar Es Salaam. The provided test report describes the disinfection efficiency of the Naïade water purification system.

3.2.2 Principle

Raw water samples from different water sources have been used for the experiments. The composition of these raw waters has been monitored by the Water Quality Laboratories Unit. The raw water samples contain a concentration of 220 to 102000 CFP/100ml total coliform bacteria (TC) and 60 – 20,000 CFP/100ml *E. coli*. The concentration of the water quality parameters is comparable with common raw water.

3.2.3 Experimental

Initial tests have been carried out with raw water obtained from the different sources (Ubungo water, Ruvu water, Yombo Dovya).

3.2.4 Results

The test results show that with influents from different water sources, the number of total coliforms and *E. coli* in the effluents is in the range of <0.01 to 49 CFP/100ml. This corresponds to at least 98% removal of total coliforms and *E. coli* (table 1).

Table 1: Removal of different organisms from the different water sources in Tanzania

Sample		Total Coliforms 37°C Confirmed cfu/100ml	*E. coli* Direct plating cfu/100ml	% -age kill
Ruvu River (I)	Influent Effluent	1040 NIL	360 NIL	 TC 100 FC 100
Yombo Dovya (C)	Influent Effluent	220 3	63 1	 TC 98.6 FC 98.4
Ubungo Stream (I)	Influent Effluent	102,000 13	1,000 3	 TC 99.9 FC 99.7
Ubungo Stream (C)	Influent Effluent	60,000 49	20,000 7	 TC 99.9 FC 99.9
Ruvu River (I)	Influent Effluent	700 NIL	550 NIL	 TC 100 FC 100
Ruvu + Ubungo (C)	Influent Effluent	2,000 1	1,200 1	 TC 99.9 FC 99.9
Ruvu + Ubungo (I)	Influent Effluent	2,000 NIL	1,200 NIL	 TC 100 FC 100

Remark C = Continuous tap pressure
I = Interval of 2 minutes

3.2.5 Evaluation of the results of the experiments

The microbiological removal efficiency on varying bacteria contents after a contact time of two minutes with UV is more than 98%. According to the results of the experiments, limitations of the disinfection properties are depending on variations in contact times. Storage of the water after disinfection needs to be avoided or minimized.

3.3 TEST REPORT VITENS QUALITY LABORATORY

3.3.1 Introduction

The Naïade Purification system, which is supplied by Nedap Power Supplies, has been tested in 2004 by the VITENS quality laboratory. The provided test report describes the disinfection efficiency of the Naïade water purification system.

3.3.2 Principle

Canal raw water has been used for the experiments. The composition of this raw water has been monitored by VITENS Laboratory.

3.3.3 Experimental

Initial tests were carried out with raw water obtained from the canal source.

3.3.4 Evaluation of the results of the experiments

The reduction of the presence of bacteria in the effluents was measured by heterotrophic plate counts. The removal based on the heterotrophic plate counts was 99.4%. These experiments did not include measurements on faecal indicators such as coliforms and *E. coli*.

3.4 TEST REPORT UNESCO IHE

3.4.1 Introduction

The Naïade Purification system that is supplied by Nedap Power Supplies has been evaluated in 2004 by UNESCO IHE. The provided report describes the evaluation of the disinfection efficiency of the Naïade water purification system.

3.4.2 Principle

The report presents the results of the testing of performance of Naïade UV disinfection system at UNESCO-IHE, Delft in The Netherlands. The study was mainly focused on the removal of the selected micro-organisms (Total coliforms, *E. coli* and Heterotrophic Plate Count), taken into account the given test conditions and the effect of this treatment system on the other selected standard water quality parameters.

3.4.3 Test conditions and procedure

The Naïade UV disinfection system has been tested from 19 October to 2 December 2004. Water from a Delft canal has been used as raw water source for the tests.

3.4.4 Results of testing

The test results shows that with Delft canal water used as influent, the number of total coliforms and *E. coli* in the effluents are both <0.01CFU/ml. This corresponds to at least 2-3 log removal of total coliforms and more than 1 log removal of *E. coli* (table 2). The removal of heterotrophic bacteria is only 0.8-1.7 log. It is not clear whether this could be influenced by the grow of bacteria in the system.

Table 2: Removal of different organisms from Delft canal water (without spiking)

Sample		Total Coliforms 37°C Confirmed cfu/ml	Thermotolerant Coliforms 44°C Confirmed cfu/ml	E-coli Direct plating cfu/ml	Heterotrophic Plate Count 22°C 3 days cfu/ml
1	Influent	10	1.5	1.8	12,000
	Effluent	<0.01	<0.01	<0.01	260
2	Influent	2.9	0.21	0.06	7,000
	Effluent	<0.01	<0.01	<0.01	1,200

In the second tests *E. coli* was spiked with canal water and 4-5 logs removal of total coliforms and *E. coli* were observed. These results demonstrate that under the conditions applied, the Naïade UV disinfection system is very effective in removal of total coliforms and *E. coli* (table 3). It should be noted that spiked *E. coli* is generally more sensitive to UV than *E. coli* originating from the field.
At the same time, heterotrophic plate count bacteria were removed by only 1 log. It is not clear whether this is due to growth of these bacteria in the system.

Table 3: Removal of different organisms from Delft canal water (with *E. coli* spiking)

Sample		Total Coliforms 37°C Confirmed cfu/ml	Total Coliforms 44°C Confirmed cfu/ml	E-coli Direct plating cfiu/ml	Heterotrophic Plate Count 22°C 3 days cfu/ml
3	Influent	160	170	190	8,400
	Effluent	<0.01	<0.01	<0.01	900
4	Influent	2,100	1,300	1,400	8,100
	Effluent	<0.01	<0.01	<0.01	650

In order to analyse the effect of turbidity on removal efficiency, samples were spiked with kaolin in different concentrations while keeping the *E. coli* concentration constant. These tests were conducted with the turbulator in place. It was observed that even when the turbidity of the water was increased from 20 FTU to higher than 300 FTU, there was more than 3 log removal of *E. coli* and total coliforms. Within the range of *E. coli* and total coliforms level tested, there was no significant adverse effect of increasing turbidity on the efficiency of the UV disinfection system.
The effect on the removal efficiency with or without a turbulator under the conditions tested implies that there was no significant difference in the results for total coliforms, *E. coli* and heterotrophic plate count.

3.4.5 Evaluation of the Naïade Purification System

The concentrations of 21 different standard parameters were analysed three times during the experiments with raw water. There was no significant change in any of these 21 standard parameters when the raw water passed the UV disinfection system. Changes or removals were observed only at the microbiological parameters. This indicates that the Naïade UV disinfection system is effective in removing selected micro-organisms, without changing other 21 standard physical/chemical water quality parameters significantly. It should be noted that there was no significant change in turbidity when the canal water was treated by the UV disinfection system.

3.5 EVALUATION OF THE PERFORMANCE RELATED TO THE STUDIES

The set up of the various tests and testing conditions in the studies were evaluated with regard to aspects relevant to the disinfection efficacy. The two options for the Naïade Water Purification System in the studies were testing of the performance of the filters and the microbial inactivation by UV-radiation. In the testing procedures of all four studies the same prototype Naïade (product code: 9889078) was used. All studies were performed under normal quality control circumstances and relevant protocols. The required ability and competence by Kiwa for the evaluation of the laboratory microbiological and chemical results is declared and demonstrated by the Kiwa Laboratory Accreditation (L15, since 1988) for ISO/IEC17025. The influents in the study by the Marmara laboratory and Tanzania laboratory were related to the practical resources. The influents in The Netherlands were related to canal quality circumstances. All these studies used raw surface water from the field, representing conditions in which the equipment will be used in practice. The studies do represent a range of water types, but not all possible conditions that can be experienced in rural areas.
The studies used the same parameters: turbidity, coliforms at 37°C and 44°C, *E. coli* and heterotrophic plate counts and these were analysed in accordance with international standards. In some cases spiking of the influent samples with additional cultivated bacteria or domestic wastewater was performed.

The laboratory tests show that the Naïade system is able to inactivate *E. coli* and coliforms with 98% or more. Heterotrophic plate counts were removed by 0.7 logs or more, although the large discrepancy between inactivation of coliform (4-5 logs) and heterotrophic bacteria (1 log) in the IHE studies with spiked bacteria suggest growth of bacteria or recontamination with heterotrophic bacteria.

The Naïade Water Purification System is adequate for its application: to purify raw water by filtration of organisms and suspended matter larger than 10µm and on inactivation of micro-organisms with log reduction values (LRV) of 1.7 or more for *E. coli*, and total coliforms and of 0.7 or more for heterotrophic plate counts. The latter should be regarded with caution, given the possibility of grow of these bacteria.

4 Operation and Maintenance

4.1 GENERAL

The Naïade water purification system purifies microbiologically contaminated water and makes it safer and more potable for the target users in rural regions. In this chapter operational and maintenance aspects are evaluated.

4.1.1 MAIN FEATURES

The Naïade water purification system is not dependent on external energy sources. It is a dual barrier treatment and effective against common waterborne pathogens. For installation, operation and maintenance the system is easy to handle. The target user shall be informed about the working and maintenance procedures. It is only effective against micro-organisms and turbidity, not against other water quality parameters. The working of the system is based on the removal of harmful micro-organisms from available water sources and the filtering of particulate matter like insects and worm-eggs. The capacity of the ultraviolet irradiation lamp is able to inactivate bacteria, most viruses and protozoa. It will not make fresh water out of salt water, nor remove salts from the water, or remove dissolved metals, or remove chemicals such as pesticides, arsenic and fluor or change the odour and flavour.

4.2 FILTERS

Naïade contains one 6mm ID filter gauze and two fine filter rings of 10 and 25 µm. The working is effective for removing particulate matter. A cleaning procedure needs to be performed every day. The filtering parts and inside surrounding of the container shall be cleaned effectively to prevent contamination of the device. Especially maintenance shall be performed to prevent grow of bacteria. Potential forming of a slime layer due to algae should be avoided.
Stagnation of the system during a long period needs to be avoided. A cleaning procedure with chemicals is necessary when biofilms (algae) are present and clog the system.

4.3 WATER RESERVOIR (capacity 100 liter)

The water reservoir is manufactured from polyethylene (LMDPE) and is suitable for the technical use. The pre-treated water is stored in this water reservoir before the disinfection is started. By pressing the only button of this system the pre-treated water flows past the UV-C lamp in a specially designed reactor.

4.4 REACTOR TUBE (with UV-C irridiation 16W lamp)

The 60mm ID reactor tube is based on aluminium anodized material and specially designed to prevent the user from direct contact with UV-C light. This light is not visible and harmful to eyes and skin.
The correct system design plays an important role in the effectiveness of the disinfection capability and to this end the modelling of the design establishes turbulent flow, which ensures good mixing and balanced exposure at high and low flows and residence time characteristics. The high internal quality of the reactor avoids shadowing and other bacterial traps. The reactor has integrally sample top parts and bottom parts to drain the water flow.

4.5 UV-C IRRADIATION LAMP (type TUV 16W 4P-SE. 16Watt)

UV-C source is built up out of a fused silicon 60mm quartz tube with inert gas. The system demonstrates a max. 300 dm3 per hour power ratings with a 16W single lamp. The theoretical dose (=IxT) energy is given in mJ/cm2 (= 1000 microwatt second/cm2) per unit per surface area The UV-C irradiation is emitted at a specific wavelength of 253.7 nm. The disinfection of the water will start when the pre-treated water passes the UV-C lamp. UV-light penetrates the cell wall of a micro-organism and causes a reaction in the micro-organisms DNA.
This renders the micro-organism incapable of growing and multiplying. Generally a dose of 40 mJ/cm^2 gives a reduction in the number of most micro-organisms of >99.99%. The efficacy of the UV-C light depends on the UV-transmission of the water. In low transmission water disinfection may become compromised by the absorption of the UV-light. Micro-organisms that are associated to particles may be protected against the UV-light.
Fouling of the system, especially of the sleeve around the UV lamp, will result in reduction of the UV-intensity that is available for disinfection. The degree of fouling was not evaluated during the tests.

4.6 UV-EXPOSURE

The disinfection efficacy of the UV-system is determined primarily by the intensity of the UV-light, the UV-transmission of the water and the duration of the exposure. It is therefore of the most importance that the duration of the exposure is long enough given the available intensity of the UV-lamp and the UV-transmission of the water.
The use of the lamp is time registered by a software integrated counter. The system automatically shuts down when the battery power is too low to sustain a sufficient UV-dose and/or when the registered lifetime of the UV-lamp is reached. The system can't be started up in situations of too low transmittances of the UV- lamp and will not discharge the water. A special signal from the system can be recognised by the user to arrange maintenance procedures.

4.7 ELECTRICAL ENERGY SOURCE

Normally the Naïade works as an independent energy source. A non-practical approach of handling the system will effect the life cycle of the system. Avoid interferences of the climate and effects due to local circumstances that are unfavourable for the system. The solar panel needs to be placed in a clear surrounding to avoid contamination on the panel.

4.8 MAINTENANCE

The daily maintenance is described by the manufacturer of the Naïade purification system. The yearly change of the UV-lamp is organized by the manufacturer (Nedap Power Supplies).

4.9 PRINCIPLES

NGO's and operators shall lecture the target user about the basic hygiene, working manual and its philosophy regarding the Naïade purification system.
It is a duty of the manufacturer to instruct the new owner of the purification system.

4.10 EVALUATION OF OPERATION AND MAINTENANCE

The manuals supplied by the manufacturer are specific for this equipment. For this study all significant main features of the Naïade water purification system are described under 4.1 till 4.8. For these evaluation aspects the procedures of operation and maintenance were verified to determine as far as possible the working of the individual parts of the system. The target user needs to be aware of the design, the installation procedures and the way of commissioning the water purification system, including a full hygienic operation and daily maintenance. The specific features used in the Naïade Water Purification System are not explicitly measured by exposure of the parts to water and by analyzing the extracts by GC-MS. The individual features were evaluated by an expert judgment on the relevant used materials. The Naïade Water Purification System is friendly to operate for the user (one key point to start and stop). The availability of spare parts needs to be taken into account by normal use of the system due to a lifetime of the UV-lamp of approximately one year. The daily clean-up procedure for the filters needs to be explained to the target user on location.
According to the specifications of the Naïade, the quality of the operation and related maintenance of the system will influence the performance of the system and the quality of the water during time. The target user needs to be aware of strict procedures for handling. Therefore special attention is given to the cleaning procedure of the system as it is laid down in the maintenance manual delivered by Nedap.

5 Conclusions

In reference to the specifications of the system, the maintenance and operational procedures described by Nedap and on the basis of the results of experimental studies, Kiwa declares that by only using the parts and procedures as mentioned in this report, the Naïade Water Purification System is capable to achieve 1.7 log inactivation or more of *E. coli* and coliforms when surface water is applied to the system. This will not result in effluent water that meets the WHO drinking water guidelines in case more heavy polluted surface water is used, but can do so when cleaner source waters are applied. The Naïade system is also useful in special circumstances (i.e. disasters) when provision of good quality drinking water is not available.

The target user needs to be aware of the design, the installation procedures and the way of commissioning this water purification system, including a fully hygienic operation and daily maintenance.
In order to use the Naïade purification system, the target user needs to be familiar with the issues regarding hygiene aspects and fouling in order to prevent recontamination and biofilm growth and fouling of the UV-lamps.
The target user needs to avoid instability and hydraulic stagnations of the system, especially by a proper and regular cleaning of the filters.

6 Limitations

With every water purification system evaluation, there are limitations in the assessment methodology, the conditions of testing and the technology itself.
Regarding the recognition of this Kiwa Declaration, the manufacturer Nedap and target user on location shall be aware of all described limitations and recommendations with respect to the handling of the Naïade Water purification System.

The microbiological inactivation in LRV is only evaluated on bacteria (*E. coli*, faecal coliforms, and total coliforms). The evaluation was done with *E. coli* bacteria in the field. According to literature data (Hijnen *et al.,* 2004), an *E.* coli inactivation of >98% would coincide with a virus inactivation of approx. 3 logs or more and inactivation of Crypto-sporidium and *Giardia* of more than 4 logs.
The inactivation could be less when the UV-transmission or concen-tration of small suspended particles in the influent water is high.
Removal of heavy metals including arsenic and pesticides, herbicides etc. was not under the scope of testing, but is expected to be minimal.

The water quality of the effluents does not fulfil the microbiological guidelines for drinking water from the World Health Organisation Guidelines for Drinking Water Quality or the European Drinking Water Directive (DWD) under all raw water conditions. The efficacy of the system does render it useful in special conditions, such as disasters that have compromised the delivery of safe drinking water or in rural settings or other situations where no source of safe drinking water is available. The system may produce water that meets the drinking water guidelines in situations where relatively clean raw waters are available.

The use of operation, maintenance and replacement procedures of the Naïade Water Purification System do increase the quality of performance.
Fouling of the lamps and the use of raw water that yields high contents of fine particulate matter or UV absorbing compounds after filtration should be avoided; otherwise the disinfection capability will decrease.
Due to touching the discharged water from the system with dirty hands may lead to deterioration of the quality of the water.

The Kiwa Declaration is only valid in comply with this evaluation report. This declaration is not a specific product certificate.

7 Supporting Documents

Dr. Kerç, Aslihan (2004): Study Naïade Water Purification System. Marmara University Environmental Engineering Department

Hijnen WAM, Beerendonk E. Smeets P, Medema GJ (2004) Elimination of micro-organisms by water treatment processes. Report BTO 2003.013, Kiwa, Nieuwegein, the Netherlands

Nedap Power Supplies (2004). "Overview used materials Naïade Water purification System".

Nedap Power Supplies (2004). "Prospect Naïade Water purification System".

Nedap Power Supplies (2004). "Vitens information Naïade Water purification System".

UNESCO IHE (2004). "Performance Testing of Naïade UV Disinfection System". Delft, the Netherlands.

Water Quality Laboratories Unit, Ministry of Water and Livestock Development (2004). "Naïade water disinfection efficiency test report". Dar es Salaam, Tanzania.