MOBILE DRINKING WATER TREATMENT PLANT (TYPE IG5M30) FOR DISASTER EMERGENCY RESPONSE

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ABSTRACT

Emergency conditions due to floods, landslides and droughts cause shortages of clean water and drinking water to meet daily needs. These conditions require immediate solution to provide clean water and drinking water to the people in the disaster area. This research activity aims to develop mobile drinking water treatment system beeing capable for processing of marginal raw water into drinking water in the affected areas, in order to help people in the region to access water. Development of systems URC-IPAMB Type IG5M30 is an important step to address the needs of water services in the disaster areas, especially floods. URC-IPAMB Type IG5M30 has been completed and the results of operating system and installation testing were satisfied. The quality of water produced has met the standard. Some adjustments and system improvements URC-IPAMB Type IG5M30 still needed in order to optimalize the installation function.

Keywords: mobile plant, operating systems, water quality, clean water, RO system

INTRODUCTION

Clean water is a basic need for human life, where the source can be obtained either from surface water or groundwater. Utilization of water to meet the needs of clean water becomes an important factor for the development and improvement of people's welfare. Water use is increasing in line with population growth and standard of life. In general, the source of water needs is coming from surface water, except several marginal areas such as flooding, or polluted area (Sutapa (2014), Sutapa 2015).

Emergency situations such as floods, landslides and droughts make basic needs (foods, drinking water and other logictics) are difficult to obtain. This condition requires a rapid solution for the people in the disaster area. Surface water conditions after disaster (floods, tsunamis, landslides) generally has a characteristic: brown to blackish colour, muddy and smelly. Such raw water is considered as marginal water, basically not eligible to serve for drinking water or used directly to meet their daily needs. Development of mobile drinking water treatment system will help people in the disaster region in obtaining clean water and drinking water required.

Water treatment is an important solution to overcome the shortage of drinking water. The processes of water treatment are the removal of contaminants from untreated water to produce pure water for human utilization (Faisal Siddiqui, M. et al.(2015), Tran, N.H. et al. (2015)). Three main substances that are withdrawn during the procedure of drinking water treatment are (Tran, N.H et al. (2015), Särkkä, H., et al (2015)): suspended solids, dissolved matter and biological matter. Several types of water contaminant are mineral pollutants, organic pollutants, biological pollutants, suspended solids, dissolved matter or biological organisms (Liu, X.et al., (2013), Särkkä, H., et al (2015)).

Other strategies to deliver water supply different form wellsprings are progressively investigated and used especially in waterfront areas. One of them is desalination of brackish or saline water (Sadhwani, J.J et al (2005), Miri, R. and Chouikhi, A. (2005), Van Dam, R. and Chapman, J. (2002)). Thermal, membrane reverse osmosis (RO) and ion exchange methods are the three main techniques for treatment for this kind of water (Lattemann, S. and Höpner, T. (2008), Trousdale, S. and Henderson, E. (2009) , Mitchell, E.J.(2002), Chapman, P.M. (2000)). The system of reverse osmosis has turned out to be the most reduced cost strategy concurring to numerous studies (Falkenberg, L.J. and Styan, C.A. (2015)). Several other advantages of RO system are: simple operation, reduced sizes, low ecological effects. Water treatment using reverse osmosis system may withdraw inorganic particles as well as natural

matters, infections and microorganisms (Tularam, G.A. and Ilahee, M. (2007), Falkenberg, L.J. and Styan, C.A. (2015)).
Osmosis is a natural phenomenon which can be defined as the movement of pure water through a semi permeable membrane from a low to a high concentration solution. The membrane is permeable to water and some ions but rejects almost all ions and dissolved solids. This process (movement of water) occurs until the osmotic equilibrium is reached, or until the chemical potential is equal on both sides of the membrane (http://lewabrane.com/). Reverse osmosis is a membrane separation process for removing solvent from a solution. When a semi permeable membrane separates a dilute solution from a concentrated solution, solvent crosses from the dilute to the concentrated side of the membrane in an attempt to equalize concentrations. The flow of solvent can be prevented by applying an opposing hydrostatic pressure to the concentrated solution. (https://www.aquatechnology.net /reverseosmosistheory.html). In order to use reverse osmosis as a water purification process, the feed water is pressurized on one side of a semi permeable membrane. The pressure must be high enough to exceed the osmotic pressure to cause reverse osmotic flow of water. If the membrane is highly permeable to water, but essentially impermeable to dissolved solutes, pure water crosses the membrane and is known as product water and the concentration of dissolved impurities increases in the remaining feed water.
The purpose of this research activity is to develop a mobile drinking water treatment plant in order to cover clean water and drinking water need in disaster areas as emergency response to overcome the water crisis. Reverse osmosis system is the main component in the moblie plant.

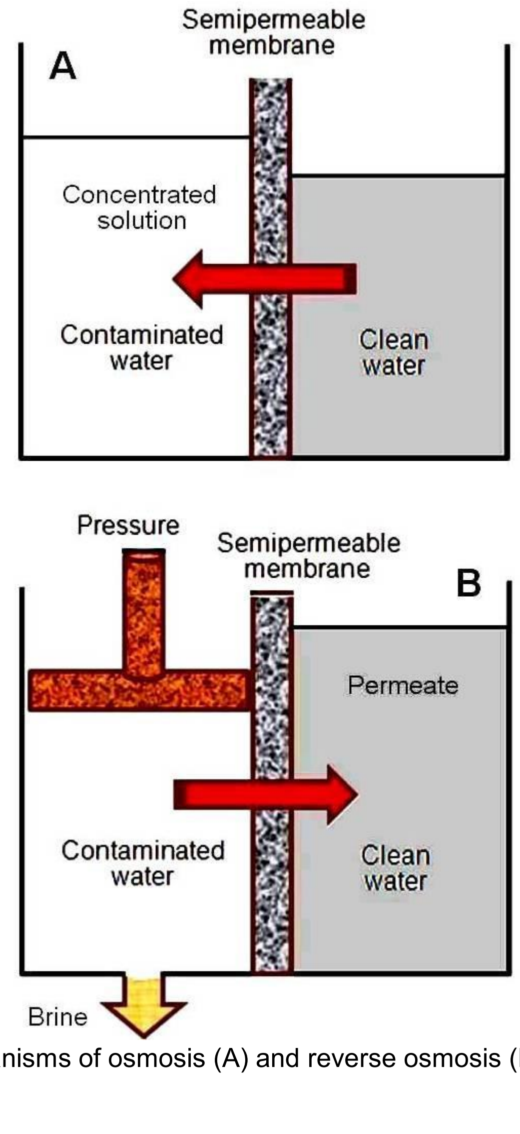

Figure 1. Basic mechanisms of osmosis (A) and reverse osmosis (B) (Sunil J. Wimalawansa (2013)

METHODS

System of URC-IPAMB Type IG5M30

The planning design for the Rapid Response Unit - Installation of Mobile Drinking Water Treatment (URC-IPAMB) Type IG5M30 with Brackish Water Reverse Osmosis system (BWRO) is designed to limit the produced water conditions as follows (**Table 1**).

Tabel 1. Design of water quailty treated by URC-IPAMB Type IG5M30

No	Parameter	Standard
1	Colour	No colour
2	pH	6.5 – 8.5
3	Turbidity	< 5 NTU
4	Smell	No smelly
5	Taste	No taste
6	Fe	0
7	Fat and oil	0
8	Organic bacterial	0
9	Chlorine and other toxic	0
10	Clean Water Flow	60 L/mn
11	Drinking water flow	20 – 30 L/mn
12	Total Dissolved Solid	< 80 mg/l

Five (5) main componens of the mobile plant for drinking water treatment are : pretreatment, BBRO system, disinfection system, distribution system and electrical system.

a. Pretreatment. The main components of the pretreatment process consist of raw water pumps, sand filter, activated carbon filter and clean water tank as shown in Table 2.
b. BWRO system. Brackish Water Reverse Osmosis (BWRO) System is composed by several components including: feeder pump, filter, booster pump, membranes, control panel, product tank and pump.
c. Disinfection system. Disinfection system used in URC-IPAMB Type IG5M30 consists of ozone sterilizer and UV sterilizer.
d. Water Distribution System . The main components of water distribution system in URC-IPAMB Type IG5M30 is Posh tretment Cartridge and Charging Filler.
e. Electricity system. Electrical systems of the URC-IPAMB Type IG5M30 consists of: Control Panel Electric System, 3 Phase Generator Set and 1 Phase Generator Set.

Technical devices URC-IPAMB Type IG5M30 compiled and assembled in mobile containers in the form of a trailer with two (2) wheels. The trailer has dimensions of 300 cm long, 180 cm wide and 150 cm high. Distance basis trailer to the ground is made high enough (60 cm), which allows the unit to reach a flood disaster area. Figures 1 and 2 show a schematic URC-IPAMB Type IG5M30 with the container. **Figure 3** shows the components of URC-IPAMB Type IG5M30.

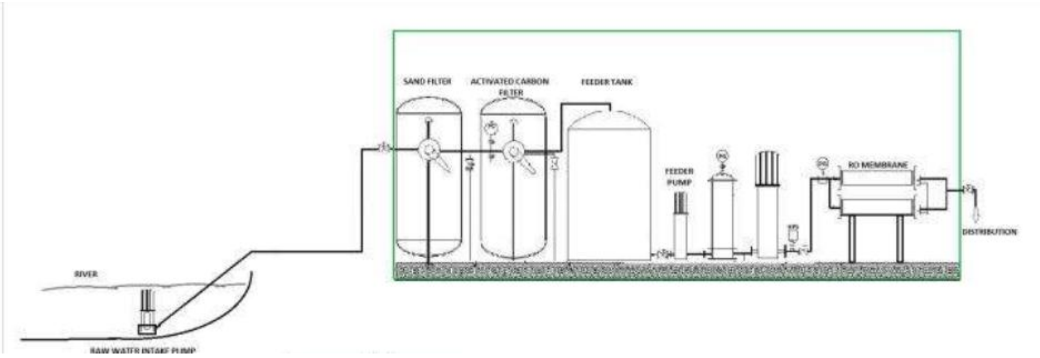

Figure 2. Scheme of operation URC-IPAMB Type IG5M30

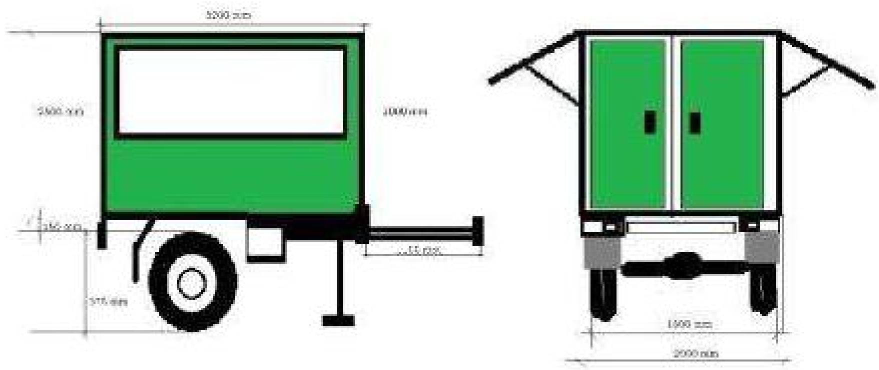

Figure 3. Schematic container of URC-IPAMB Type IG5M30

Figure 4. Mobile Plant System of URC-IPAMB Type IG5M30

Location of mobile plant testing

The testing location of mobile plant was arround Cibinong Science Centre area in Bogor District. Water samples analysis were conducted in the Laboratory of Research Centre for Limnology LIPI Cibinong Bogor, West Java.

Sampling and analysis of samples

As describe by Sutapa (2015), the method for water samples analysis is based on APHA 2005 and consists of several stages:

- Direct observation on some potential area to select the location that meets the standards to be processed as a raw water source.
- Physical parameters include; color, taste, conductivity or electrical conductivity to TDS meter, turbidity using turbidimetry, temperature, and salinity using Water Quality Checker (WQC) in situ measurement.
- Chemical parameters include mainly the content of non-metallic. Analysis of non-metal content; pH, sulfate content, total organic matter (TOM), ammonia, nitrate,

nitrite, hardness, cyanide, fluoride, total N, Phosphate, Total P, and phenol with titrtimetri method.

- Biological parameter that is based on the presence or absence of pollution indicator bacteria E. coli and Coliform. 0:45 nm porous cellulose membranes placed on a sterile filter tools by using tweezers. Filtered water samples with a volume of 100 ml and 50 ml.

RESULTS AND DISCUSSIONS

Physical Parameter Analysis

Table 2 summarizes the result of physical parameter analysis. Water color intensity of raw water has a range of 20 - 25 TCU (Total Color Unit). This color intensity decrease up to 4 – 5 TCU and meet the standard Regulation of Health Minister RI No. 492 of 2010, setting the standard normal threshold of clean water a maximum of 15 TCU. Slightly tasty raw water becomes tasteless after treatment as shown in the Table 4. Some other physical parameters showed same trend in decreasing: turbidity form 15 – 20 NTU to 0.0 – 1.0 NTU, TDS form 60 – 65 mg/l to 20 – 22 mg/l and temperature in the range of 30 – 32 C. In general, all physical paramaters analysis of water quality after treatment meet the standard.

Tabel 2 Physical parameter analysis of water quality

Physical Parameter	Raw Water	Treated Water	Standard (Minister of Health Regulation No. 492/2010)
Total Dissolved Solid (ppm)	60 – 65	20 – 22	500
Turbidity (NTU)	15 – 20	0.0 – 1.0	5
Color (TCU)	20 – 25	4 – 5	15
Taste	Slightly Tasty	No taste	No taste
Temperature (°C)	30 – 31	31 – 32	Air temp. +/- 3

Chemical Parameters Analysis

The results of chemical analysis of water before and after treatment are shown in Table 3. The normal range of several chemical parameters is summarized. The treatment process tend to increase the quality of water and meet the standard. The pH value of raw water which is in the range of 7.5 – 7.8, slightly decreases to 6.9 – 7.1. This value is in the water quality standards of 6.5-8.5. Sulfate concentration of raw water is in the range of 15.50 - 17.54 mg / l and becomes 8.20 - 10.99 mg/l after treatment. The concentration of Total organic matter (TOM) is between 6.36 - 8.50 mg / l and and decreases to 2.40 - 3.97 mg/l. Some other parameters are below the standard after treatment : of ammonia 0.75 - 1.00 mg/l (from 2.50 - 3.79 mg / l), nitrate 0.06 – 0.10 mg / l (from 0.12 – 1.5 mg/l), and nitrite <0.00001 – 0.001 mg / l (from 0.01 – 0.15 mg/l), Total N 1.90 - 2.17 mg/l (from 3.30 - 4.46 mg/l) and Total P 0.09 – 0.10 mg/l (from 0.07 – 0.26 mg/l). The result of chemical parameters analysis show that mobile plant increases water quality of raw water and meet the standard for drinking water.

Tabel 3. Result of chemical analysis

Chemical Parameter	Raw Water	Treated Water	Standard (Minister of Health Regulation No. 492/2010)
pH	7.5 - 7.8	6.9 – 7.1	6.5 – 8.5
Nitrate(mg/L)	0.12 – 1.5	0.06 – 0.10	50
Nitrite(mg/L)	0.01 – 0.15	<0.00001 – 0.001	3
Ammonium (mg/L)	2.50 - 3.79	0.75 - 1.00	1.5

Total N (mg/L)	3.30 - 4.46	1.90 - 2.17	na
Total P (mg/L)	0.07 – 0.26	0.09 – 0.10	na
Sulphate (mg/L)	15.50 - 17.54	8.20 - 10.99	250
Total Organic Matter (mg/L)	6.36 – 8.50	2.40 - 3.97	10

Biological Parameters Analysis
Analysis of the biological quality of drinking water requirements follows the rules by using the parameters of E. coli and total coliform bacteria (Sutapa 2015). Coliform is a group of bacteria used as an indicator of pollution, waste and bad conditions of water, food, milk and dairy products. Table 4 shows the result of bacterial analysis. Raw water contents 75 – 100 70 Col / 100 ml of E. Coli and 200 - 250 Col / 100 ml of Coliform. These results indicate that the water does not meet the standard in accordance with Regulation of Minister of Health No. 492 in 2010. The quality of treated water by mobile plant increases and does not content either *E. Coli* or Coliform.

Tabel 4 Result of biological parameter analysis

Biological Parameter	Raw Water	Treated Water	Standard (Minister of Health Regulation No. 492/2010)
E-coli (cfu/ml)	70 – 100	0	0
Total Coliform (cfu/ml)	200 – 250	0	0

CONCLUSION

This study shows that mobile device URC-IPAMB installation Type IG5M30 can increase the quality raw water up to drinking water quality in accordance to Minister of Health Regulation No. 492/2010. The results of laboratory analysis related to physical, chemical and biological parameters are inline with the regulation standard. The development of mobile drinking water treatment system that is capable for treating of marginal raw water into drinking water is very promoting. This mobile plant can be alternatif in the affected area to help people in the region in obtaining clean water and drinking water required. However, some adjustments and system improvements URC-IPAMB Type IG5M30 are still needed in order to optimalize the installation function. Beside this, water quality test should be conducted periodically to ensure that the installation is functioning properly.

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