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By Joni Adiansyah

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To cite this article: D Rahmawati *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **674** 012048

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The 17th International Symposium on Solid Oxide Fuel Cells (SOFC-XVII)
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Reducing the natural disaster impacts by using an appropriate water testing technology

D Rahmawati^{1,3*}, J S Adiansyah¹, Alpiana^{1,3} and Isfanari²

¹ Mining Technology Departement, Engineering Faculty, Universitas Muhammadiyah Mataram, Indonesia

² Civil Engineering Departement, Engineering Faculty, Universitas Muhammadiyah Mataram, Indonesia

³ Muhammadiyah Disaster Management Centre, West Nusa Tenggara (MDMC NTB), Indonesia

* Email: dee.rahmawati@gmail.com

Abstract. The natural disaster might cause various impacts to the human including water supply. Polluted water sources should be treated prior consumed. The water treatment process refers to the water testing results. This paper was aimed to determine an effective water testing technology for emergency situations associated with natural disasters. The methods used were literature review and experiment. Various water testing methods during emergency response were explored by a terature review. In addition, the accuracy of manual and digital water testing kit, including pH and turbidity, were conducted through an experiment. The research resulted that the effectiveness of turbidity tubes ranged from 80 to100%. While the pH kit effectiveness ranged from 80 to 94%. There is no rule to classify the best technology during emergency response. The chosen technology depends on each humanitarian agency's condition including financial and human resources.

1. Introduction

A natural disaster is an incident resulting from the natural process which caused a negative impact on human life. The damage level depends on the community and environment affected [1] [2]. Shortly after the disaster, the condition of the community is unstable and vulnerable, and they require immediate aid from various stakeholders including government, company, and NGOs. The government and private sectors often collaborated, and they usually shared responsibility among them to respond to the disaster [3]. In addition, the humanitarian agencies oblige to follow three protection principles which stipulated the Humanitarian Carter as follows: a right to receive humanitarian assistance, a right to life with dignity, and a right of protection a security. Therefore, the humanitarian agencies have four emergency response standards including 1) Water Supply, Sanitation, and Hygiene Promotion (WASH), 2) Food Security and Nutrition, 3) Shelter, Settlements, and Non Food Items, 4) Health Services [4] [5].

A natural disaster including floods and earthquake could affect the freshwater supply. For instance, the flood affects water turbidity and the earthquake could damage freshwater distribution networks. In addition, the tsunami is a potential trigger for mixing the seawater and freshwater that might disturb the freshwater supply [6]. The availability of freshwater supply is very crucial within the first 3 days of natural disasters. Lack of freshwater supply during the natural disaster increases the diseases



including diarrhea that transmitted by feces to mouth [5]. The common problem associated with freshwater supply during the natural disaster is the water quality that usually below the standards, so the water must be treated further. The Ontario storm in 2000 was one of the examples of freshwater pollution caused by bacteria. The pollution has caused 7 people died and more than 2300 people sick due to E.Coli and Campylobacter [6]. Two technical root causes were found, namely inadequate water quality measurement and treatment. Another lesson learned from Bima flood in December 2016 also indicated the gap in knowledge of water supply technology. In this case, The Muhammadiyah Disaster Management Center of West Nusa Tenggara (MDMC NTB) was unable to supply the fresh water for bathing, washing, and other personal use, because no applicable water treatment technology in the field. Therefore MDMC NTB provides package water for drinking and cooking (consumed water). In general, this paper aimed to determine an effective water testing technology in the emergency response associated with natural disasters.

2. Method

The methods of this paper are literature review and experiment. Various water testing methods during emergency response were explored by a literature review. The effectiveness of manual and digital water testing kit, including pH and turbidity, was observed by the experiment. The digital kit used pH meter and turbidity meter. The manual kit used turbidity tube and pH and Chlorine kit for pool and spa. The data analysis was used descriptive design which is shown in the table.

3. Result and Discussion

3.1. Water testing for emergency response

The sources of water should be assumed infeasible to be consumed during the emergency condition, so the humanitarian agencies must treat the water from various sources [3] fulfill needs. Currently, the most effective water treatment system for an emergency condition is Point of Use Water Treatment Technologies (PoUWT), for instance, coagulant-flocculants, filtration, and disinfectant [7][8]. In order to determine the water treatment phases, the water quality must be measured. The water quality measurement kit can be categorized into two types, namely, manual portable kit (e.g. indicator test for chlorine residual in water, turbidity tube [9], pH indicator); and digital portable kit (pH meter, Turbidity meter, Chlorine meter). Some humanitarian organizations have developed the technologies to measure the water quality and treat the polluted water in the emergency situation as displayed in Figure 1.

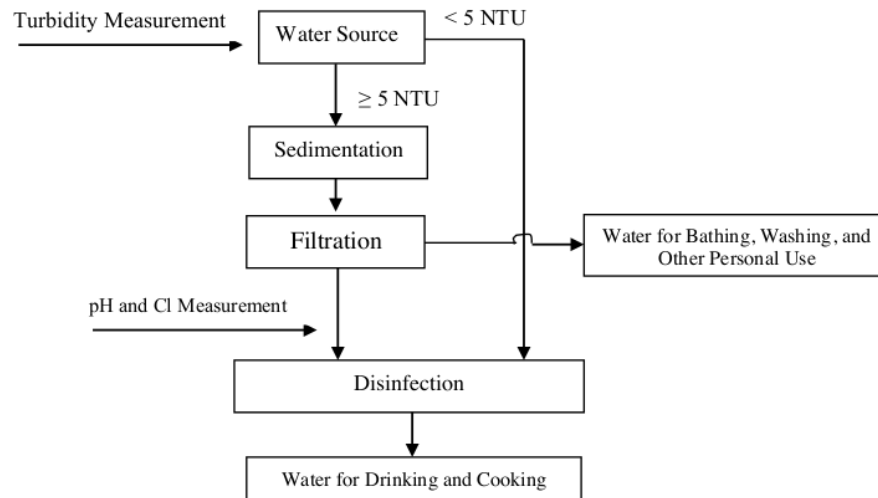


Figure 1. Water Treatment Flow Chart

The water source can be surface water (River, Lake, Spring) or groundwater (Well, Boreholes). The first step is conducting the turbidity measurement. If the water turbidity is ≥ 5 NTU, the water must be flow into sedimentation process, and the coagulant is added. Secondly, the water is filtered using cotton cloth for low capacity treatment and sand filter for higher capacity treatment. The water from filtration process is ready to be used for domestic purposes including bathing, and washing, but it must be treated further by disinfectant prior consumed (drinking and cooking). There are several methods of disinfecting processes, such as, chlorination, boiled the water, and leave the water under the sunlight which called SODIS method [4] [8]. Escherichia Coli (E.Coli) bacteria will inactive when exposed by heat 70°C or higher for a minimum 3.5 seconds [10].

The standard of water quantity used in emergency response is 7,5 – 15 l/day/person. Meanwhile, the standard of water quality is shown in Table 1 [10].

Table 1. Water Quality Standards in Emergency Response

Parameter	Threshold
Coli bacteria-contaminated with feces/100 ml of water	0
Turbidity	< 5 NTU
Residual Chlorine	Max. 5 mg/l
pH	6 - 8

3.2. Turbidity and pH measurement

3.2.1. Turbidity Measurement.

The turbidity measurement in this paper was done by using a turbidity tube and turbidity meter. The turbidity tube is a transparency tube with a black cross/viewing disc at the bottom. The observer keeps pouring the water sample until they can no longer see the black cross/viewing disc, then the observer read out the scale on the outside of the tube in NTU (Nephelometric Turbidity Unit). Meanwhile, turbidity meter is a digitalize kit in which the observer pour the water sample into a small clean container, put the water sample on the turbidity meter then read the turbidity. Table 2 provides the result of turbidity measurement in some water samples.

Table 2. Result of Turbidity Measurement

Water Samples	Turbidity meter (NTU)	Turbidity tube (NTU)	Turbidity tube effectiveness
1	11,5	9,7	84%
2	7,8	6,9	88%
3	8,6	7,3	85%
4	15	12	80%
5	0,47	<5	100%
6	61,3	57,9	94%
7	104	100	96%

Table 2 indicated that the turbidity measurement by tube and turbidity meter generated different results. A turbidity meter is more accurate to measure less than 5 NTU; then turbidity tube can be measured only a maximum of 5 NTU. The results of measurement as shown in table 1 indicated that the effectiveness turbidity tube ranged from 80 to 100%. However, the observation result using

turbidity tube varies for each person. In order to reduce the high difference, the observation must be conducted by at least two observers

3.2.2. pH Measurement

pH measurement in this paper was done by using pH meter and manual kit pH and chlorine for the pool. pH measurement by pH meter follows the steps: pour the water sample into a clean container, then put the probe into the water and read the pH. Meanwhile, to measure pH in the manual, the observer fills the vial to the mark with water sample and adds 4 drops of red phenol solution, then place cap on vial and invert several time to mix. Finally, compare the observer’s reading with the pH color standards. Table 3 provides the result of pH measurement in some water samples:

Table 3. Result of pH Measurement

Water Samples	pH meter	pH kit	Effectiveness of pH Kit
1	6,04	6,8	88%
2	6,01	6,8	88%
3	6,06	6,8	89%
4	5,99	6,8	88%
5	7,113	7,6	94%
6	7,119	7,6	94%
7	6,99	7,6	92%

Table 3 indicated that the pH measurement using pH meter and pH kit resulted in slightly different values. The data showed that the effectiveness of the pH kit was around 88 - 92%. The measurement scale of pH kit can be read with the lowest limit of pH kit is around 6,8, so the acidity less than 6,8 was approached as 6.8. In general, the difference measurement result of using manual kit and the digital kit was found. Table 4 presented the advantages and disadvantages of those measurement technologies.

Table 4. Differences between Digital and Manual Portable Kit

Technology	Advantage	Disadvantage
Digital Portable Kit	Very accurate Easy to use	High cost Need Power Supply (e.g. battery) Need calibration
Manual Portable Kit	Low cost Easy to use No need power supply No need calibration	Less accurate

The precision of digital portable kit is very high, so the result of measurement very accurate. In contrast, the measurement using a manual portable kit depends on the observer, so the result could be less accurate. Both technologies are easy to use. However, the digital portable kit needs a power supply to operate, and it must be calibrated in order to maintain accuracy. The price of the digital kit is very high, and it becomes a barrier for many projects in the developing country. The lowest price of measurement kit and self-made measurement kit using local raw materials were chosen, it was more likely as well [9] [11] [12].

4. Conclusion

Water supply technologies consist of a water testing kit and water treatment is required to assist emergency responses situation. Some of those technologies are less effective in the emergency

situation associated with natural disasters. Most water supply technology developed in normal condition which is different from actual disaster conditions. There is no rule to classify the best technology in emergency response. The chosen technology depends on each humanitarian agency's financial and human resources support. Based on natural disaster risks in West Nusa Tenggara, the appropriate technology for water testing should be low cost, easy to use, and simple in design. Although the manual portable kit is less effective in measurement than the digital one but the cost is more effective.

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