MSWT-01, flood disaster water treatment solution from common ideas

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Abstract. Indonesia has a lot of potential flood disaster places with clean water problems faced. Various solution programs always initiated by Government, companies CSR, and people sporadical actions to provide clean water; with their advantages and disadvantages respectively. One solution is easy to operate for instance, but didn’t provide adequate capacity, whereas the other had ideal performance but more costly. This situation inspired to develop a water treatment machine that could be an alternative favor. There are many methods could be choosed; whether in simple, middle or high technology, depends on water source input and output result quality. MSWT, Mobile Surface Water Treatment, is an idea for raw water in flood area, basically made for 1m³ per hour. This water treatment design adopted from combined existing technologies and related literatures. Using common ideas, the highlight is how to make such modular process put in compact design elegantly, and would be equipped with mobile feature due to make easier in operational. Through prototype level experiment trials, the machine is capable for producing clean water that suitable for sanitation and cooking/ drinking purposes although using contaminated water input source. From the investment point of view, such machine could be also treated as an asset that will be used from time to time when needed, instead of made for project approach only.

Keywords: water treatment, raw water source, capacity

1. Introduction
Indonesia has a lot of places with potential disaster that flood might be happened frequently, and clean water lacking is one of problems faced in such places due to its water sources contaminating. Since water is a human basic needs, water procuring and managing became a very vital issue. For providing clean water, especially for places that had potential flood disaster in rainy season, various solutions always initiated by all related parties such as Government mitigation programs [9], CSR program from some companies, and survival actions of people around these unlucky places. These actions had their advantages and disadvantages respectively, or each strong points and constraints as well. One solution is easy to operate for instance, but didn’t provide adequate capacity, whereas the other had ideal performance but could more costly [1].

For locations where no water source, clean water are supplied from other place using trucks for transportation and distribution, whereas in other areas that have improper water source condition people are treating their water sporadically in very small capacity level. For other cases, some companies CSR program are arranged by social foundations to organize the projects, collect the branded standard water machines and operate the distribution [3]. These actions are very appreciated.
and they are improved continuously for more efficient result from time to time [6]. Using big trucks may constrained by disaster location infrastructure, whereas provide imported equipments that available in the market, although are capable to produce better quality output or guaranteed result but has the costly consequence with very specific or limited implementation, and usually initiated by project based approach. For such case, new equipment should be re-procured for next event, as a new project.

From the requirement side, clean water and drinking water quality standard are defined, such as in SNI 01-3553-2006 Indonesian ‘Badan Standardisasi Nasional’ [4] as a reference in treating surface and ground water. In some cases there are still obstacles to reach such quality standard either caused by high turbidity or iron/ manganese (Fe/ Mn) contamination, or organic/ ammonium/ undissolved compound content. Some conditions show that people are even pushed in using their water for sanitation only, whereas for cooking and drinking are unsolved.

Above mentioned problems are inspiring to develop water treatment that could be an alternative favor. It innovates a water treatment prototype for appropriate needs, that might use available raw water such as river or flood water at disaster location, in order to provide clean water demand easier for the people. Some factors that should be considered in such development idea are technology that will be choosed, system capacity (in m$^3$ per hour) that possible to produce and mobile mechanism system in order to make easier in operation and moving to reach disaster sub locations or sub sectors where it’s needed. Furthermore, energy or electric source for the system may also be settled.

2. Methodology

For water handling as people do for their need, there are many methods that could be choosed; whether in simple, middle or high technology, depends on water source feed input and water output result quality. Source water with low turbidity level for instance, might use rapid or slow sand filtration, the easy and simple methods that do not need any high skill [11] [12]. Other ways that more sophisticated are possible to conquer more complicated water source input. A few water treatment technologies in ‘figure 1’ [7] shows that conventional filtration process may overcome undissolved compound content up to around 1$\mu$m dimension, whereas the most extreme condition such as seawater or brackish with salts content has to use RO (reverse osmosis) membrane.

| Size, $\mu$m | 0.31 | 0.1 | 0.01 | 1000000 | 10000 | 1000 | 100 | 10 | 0.1 | 0.05 | 0.01 |
|-------------|------|-----|------|----------|-------|------|-----|----|----|------|-----|
| Approximately molecular weight | 200 | 1000 | 10000 | 100000 | 100000 |      |     |    |    |      |     |
| Relative size of material in water | Micro | Mesoscopic | Large | Clay | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Treatment process | Reverse osmotic | Nanofiltration | Ultrafiltration | Microfiltration | Conventional filtration processes | | | | | | |
| Metal ions | Arsenic | Nitrate | Nitrite | Cyanide | Dissolved salts | Cadmium salts | Sulfate salts | Magnesium salts | Aluminum salts |  | |
| | | | | | | | | | | Bacteria | Cryptosporidium |
| | | | | | | | | | | Salmonella |
| | | | | | | | | | | Giardia |
| | | | | | | | | | | Sheep isolates |
| | | | | | | | | | | Cysts |

Figure 1. Water treatment process technology level [7] (Heijman S.G.J, CT4471, Nanofiltration and Reverse Osmosis, 2007)

Generally, water treatment design referred to raw water sample lab analysis, then its technology will be choosed conditionally [2]. Using existing methods like conventional filtration, micro filtration (MF) or ultra filtration (UF) will solve the problem with suitable solution. One situation may need
conventional filtration only whereas the other could be added with MF for instance [10]. The smaller permeated particle size, the higher pump pressure needed, and possibly the smaller its recovery value as well. As known, conventional filtration process and MF do not have any rejection, thus all of input water goes into the system. The UF membrane, though had no rejection neither but a small percentage of input should be circulated back to initial route. Using RO cartridges gave the best result but it needs higher pressure for pumping and some percentage will be eliminated as reject waste.

In a few cases these also combined with basic method such as coagulation & flocculation to improve rejection or make the filter lifetime longer. ‘Figure 2’ shows the simple and very general stages in water treatment technology selection as described. Considering output water quality result, it might also be added UV or other disinfection system to the system.

![Figure 2. General stage in water treatment technology selection](image)

There are three system examples from market that could be studied and considered for benchmarking. The first is a product from Japan, a Portable Water Treatment [5] (KYUSUI Manual Book, 2011), that used such technologies for disaster equipment which made for 150 liters (0.15m³) per hour capacity. It is designed with MF and UF for filtration, followed with UV lamp for disinfection, thus without any chemical implemented which its block diagram showed in ‘figure 3’. This kind of machine is very elegant, easy to operate and only approximately 22 kg weight, but in general its capacity seems rather too small for flood disaster.

![Figure 3. Portable Water Treatment example Block Diagram](image)

Other technologies that could be viewed is WWT (well water treatment) and RWT (river water treatment) machine that manufactured by Czech Republic [8]. These products have the minimal capacity of WWT for 1m³ per hour (WWT-01) whereas RWT for 5m³ per hour (RWT-05). This RWT-05 is designed for surface water source such as river or lake, and could be adopted for flood water with some necessary improvement. The disadvantage is that physically it has big dimension (L-W-H of 2x3x1.8 in meter) that might give rise to obstacle in mobile operation due to its total weight and infrastructure access width. In the other hand, the WWT-01 has appropriated dimension (1x2x1.8 in meter) but its capability is only for well water sources.

The following pictures show the block diagram of WWT-01 (figure 4) and RWT-05 (figure 5). From such figures the following components in both products could be explained:

- **Hydrocyclone**: removal of most solid suspended substances with part size larger than 0.2 mm.
- **Static Mixer**: intended for spontaneous mixing different chemical solutions.
- **Retention Tanks**: precipitate iron and manganese through oxidation reaction.
- Sand Filter/ Active Carbon Filter Chamber: ensures water filtration from undissolved substances.
- Dosing Pump: dose chemical solution with automatic dosage measure.
- Sieve Filter, Automatic Self Cleaning: eliminates all undissolved substances > 100μ
- Turbo Mixer (used only for RWT-10 system, or more): for effective mixing and homogenization of dosed floculants with crude water.
- Floculations Chamber: for optimum drain of cores created during coagulation and condensation.

WWT-01 has a more simple process than RWT-05 since ground water do not need any coagulant nor floculants. In RWT-05, there is even an initial valve that has to be switched according to raw water quality. For certain condition, input water will be oxidized first before stored in Tank-A (see figure 5) and flow to the main system. Otherwise, the input go directly to sieve filter as a surface water standard treatment. In this condition, Tank-A functioned parallely with Tank-B.

The differences between these two kind of machines are that WWT-01 uses retention tank for oxidation reaction, whereas RWT-05 equipped with sieve filter due to potential raw water higher turbidity, turbo mixer and floculation chamber that needed for floculation and coagulation process that not necessary in WWT. These components are used for surface water source processing since it
might have more than 10.0 NTU (Nephelometric Turbidity Units) of maximum 5 NTU that recommended by quality standard for clean water.

The study to develop water treatment (WT) equipment refers to previous researches and market products, which technology level will be used or combined. It is designed for river or raw water source in flood area, basically made for limited community, that is 1m³ per hour or 18-20 m³ per day capacity, which is equal with approximately 100-150 man requirements. This number is considered for temporarily operation, it then has to be made easier in operation due to limited weight and easily move the unit to different places. Combining the mechanical and electrical parameters of Japan Portable Water Treatment, Czech RWT-05, WWT-01 and other references were inspiring for developing ‘new sub varian’ prototype for disaster mitigation.

Mentioned reasons caused MSWT-01--Mobile Surface Water Treatment-- identity, chosen. 'Surface Water’ tells the input which water source in flood area is included, whereas 01 indicates 1m³ per hour capacity. Combining several existing technologies, related literatures and necessary modification, the design should be also appropriated with local parts availability due to maintenance aspect. Above mentioned ‘water treatment process technology level’ (Figure-1) and exploring/searching information resulted that the basic processes in common ways like coagulation, flocculation, and filtration will still be used. The technologies are possibly not special, thus the important thing is how to combine such methods and put these modular processes in a compact design elegantly.

3. Discussion
Due to the similarity, the RWT basic/ general system & components could be easily adopted into WWT (hydro cyclone, dosing pump, static mixer and sand/ carbon filter). The firm differences are flocculation chamber, sieve filter and turbo mixer in RWT that can’t be found in WWT. The study just simplified its system that flocculation chamber and turbo mixer, which are relatively expensive, won’t be used in MSWT-01, as a part of cost reduction aim.

Figure 6. MSWT-01 for Disaster Mitigation Block Diagram

The study still has to prove experimentally that the only necessary additional component could be sieve filter, although, since its unavailability in local market, other type of screen filter will be used, without automatic self cleaning capability. Regarding the replacement of turbo mixer and flocculation chamber, implementing the sedimentation tank could be considered in order to make the sand filter performance longer, as shown in ‘figure 6’.
Through prototype level experiment trials, the machine capability has to be proved for producing clean water that suitable for sanitation and cooking/drinking purposes although using contaminated water input source. One of important thing is how to combine such methods, implementing for people needs, and developing network with disaster mitigation management stake holder for wider arrangement. From the investment point of view, such machine could be also treated as an asset that will be used from time to time when needed, instead of made for project approach only.

‘Figure 7’ shows all components for MSWT-01, but in the real prototype the sedimentation tank and UV lamp not implemented yet. Considering the poor quality of input raw water at flood disaster location, implementing the disinfection process is more elegant, although the output clean water as default will not be used for drinking purpose. UV lamp is shown on ‘Figures 7’, but as described, other alternatives for disinfection system could be choosed such as Ultra Filtration, adding NaClO etc, with their each advantage and disadvantage respectively.

Table 1. Sample results from 4 different places

| Parameter   | Unit | Std. max | Sample-1 | Sample-2 | Sample-3 | Sample-4 |
|-------------|------|----------|----------|----------|----------|----------|
|             |      | spec.    | Source   | Result   | Source   | Result   |
| Color       | TCU  | 15       | < 5      | 0.5      | < 5      | 0.65     | 6.9      | 2        | 14.6     | 6        |
| Turbidity   | NTU  | 5        | 0.28     | 0.2      | 3.17     | 0.35     | 37       | 1.2      | 57.7     | 2        |
| Fe content  | mg/L | 0.3      | < 0.1    | 0.1      | 0.69     | 0.23     | 0.15     | 0.1      | 0.49     | 0.2      |
| Mn content  | mg/L | 0.4      | < 0.03   | 0.03     | 0.02     | 0.02     | < 0.01   | 0.01     | 0.065    | 0.3      |
| Hardness)*  | mg/L | 500      | 64       | 60       | 32       | 32       | 46.5     | 45       | 114      | 111.7    |

The MSWT-01 trial from 4 raw water samples mentioned that the samples from several places had different condition or content, and might be in extreme differences. ‘Table 1’ shows several essential parameters only of not so terrible samples. From each sample, it is analyzed either the source and result, where each result samples is taken after a period of machine operation, in order to get good representation and avoid from mixing up with previous sample remained in the machine. It showed that from the highest turbidity (sample 4 with 57.7 NTU) for instance, MSWT could reduce to the acceptable level. The experiment should be done for more samples that have extreme turbidity for instance, in order to attempt with the real condition in flood area. In necessary condition, a location
that has flood water source with a high turbidity for instance, sedimentation tank could be added to the system.

4. Conclusion
MSWT-01 (Mobile Surface Water Treatment) Prototype for Disaster Mitigation is designed for river or surface raw water source in flood area, made for 1m³ per hour or 18-20 m³ per day capacity, which is equal with 100-150 man requirements. Adopted and combined from RWT-05/ river water treatment with 5m³ per hour capacity, WWT-01/ well water treatment 1m³ per hour from Czech Republic product, several references and common existing technologies, is capable to produce clean water that suitable for sanitation and cooking/ drinking purposes although using contaminated water input that taken from improper or dirty sources. It is proved through number of experiment trials at prototype level. More samples that represent real disaster condition are needed to develop in next stages. For necessary condition, it could be added with sedimentation tank and disinfection system.

Comparing with other three example market available products, MSWT-01 could provide higher capacity than Japan Portable Water Treatment (150 liters or 0.15m³ per hour), higher capability than WWT-01 that made for ground water only but had the similar dimension, and more simple than RWT-05 which used Sieve Filter/ Automatic Self Cleaning and Flocculation Chamber.

Next step is that this MSWT will be equipped with mobile feature and electric generator in order to make easier in operational and moving to reach disaster sub locations or sub sectors where it’s needed, thus clean water demand could be provided in nearly any condition. Moreover, since the technologies are possibly very common and not special, the important thing is then how to combine such methods, implementing for people needs, and developing network with disaster mitigation management stake holder for wider arrangement. From each stake holder entity or social organization point of view, the machine could be also treated as an investment that will be used from time to time when needed, instead of made for project approach only that new equipment should be re-procured for every event, as a new project.

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