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Development of low cost mass suppliable water purifier for flood disaster

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Abstract: Disastrous flood in Malaysia, since December 2014, leaved huge number of victims with deficiency of water, food, energy and transportation. Lack of potable water is one of the most serious problems, since it is the most vital factor or human life. Since water is relatively heavy goods to be delivered with wrecked transportation system, mass-supplying effective water purification system to the victims would be practical. The system should satisfy following conditions: 1. Low cost and easy to make; 2. Easy to transport, install and operate; 3. Small energy consumption (or powered by renewable energy, inexpensive batteries or human power which are easily accessible on the user's places); 4.Outdoor usable; 5. High credibility, especially on sterilization aspect. Some appropriate technologies, such as charcoal filtering water purifiers are one of good candidate. However, unfortunately, it is hard to maintain the filters always in good status, since input water quality, daily filter usage and maintenance may vary. Therefore, we may need more reliable solution than simple filter system. Once the prototype developed, mass-supply of the system could be delivered to the flood victims in future. The development can be done by collaborative effort between Malaysia and Korea.

Key words: Water purifier; Flood management; Water technology

1. Introduction

As part of the northeast monsoon heavy rains since 17 December 2014 forced many people to flee their home. The number of evacuees nationwide reached more than 200,000 by 28 December, with 10 people killed. The flooding is considered the country's worst in decades. The flood caused deficiency of transportation, energy and water supply. Prices of essential items were artificially raised. For example, one bottled of water costs MYR5, one large candle costs MYR14, l.5 liters of petrol costs MYR12. Some boat owners charged MYR5 for crossing Pahang River and MYR15 for longer journeys [1].

Supplying potable water is one of the most serious problems in such disastrous situation. Water is the most vital factor for human life, but it is relatively heavy goods to be delivered with wrecked transportation system. Therefore, it is not practical to distribute drinking water to the place, but it would be more practical to encourage potable water to be produced on each site of demand. To purify water practically on site, the purifier should be low cost, easy to operate and easily buildable on site. Actually, there were some appropriate technologies developed for satisfying such conditions. For example, J. Kearns reported charcoal bucket filter which can purify water with 1 liter per 0.1~1g of charcoal. (aqsolutions.org). though such filtration system is very cost effective, it might cause some problem if it is abused long time without maintaining properly. Common users could be negligent on replacing the filters in actual situation. Therefore, we need somewhat more reliable system. Generally, sterilization is one of the most important factors to be consider the water purification in flood situation, since water borne infection frequently epidemics on flood and after-flood. Therefore, it is required to develop certain water purification system with high reliability especially in terms of sterilization. By converging low cost filtration technology and sterilization technology, we would be able to develop more reliable, but versatile water purification system

2. Related works

Water in sufficient quantity and good quality is essential for live. However, at the beginning of the year 2000 one sixth of the world's population, 1.1 billion people, is without access to improved water supply and much more lacking access to safe water [1]. The following technologies are regarded as 'improved water supply': household connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection. The water quality in improved water supply systems often is affected from unreliable operation and lack of maintenance, or the water is subject to secondary

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contamination during collection, transport and storage.

No access to good quality drinking water leads to a high risk of water-borne diseases such as diarrhoea, cholera, typhoid fever, hepatitis A, amoebic and bacillary dysentery and other diarrhoeal diseases. Each year 4 billion cases of diarrhoea cause 2.2 million deaths, mostly among children under the age of five [2]. This is equivalent to one child dying every 15 seconds, or 20 jumbo jets crashing every day. These deaths represent approximately 15% of all child deaths under the age of five in developing countries. Apart from the high infant mortality, diarrhoea affects a numerous children in developing countries in their physical development. Frequent diarrhoea is a cause for children's malnutrition, while malnutrition again increases the likelihood for children to die from an infectious disease such as diarrhoea or an acute respiratory illness. Recent estimates suggest that malnutrition is an associated cause for about half of all deaths occurring among children in developing countries [3].

The public health condition in developing countries can abruptly lead to the dramatic spread of epidemics. Cholera for example remains a risk for such epidemic outbreaks. It is endemic in 80 countries and still of concern to all regions of the world. The number of deaths caused by cholera has declined over the last decades due to the application of simple and adequate curative treatment methods (oral rehydration therapy). Adequate water treatment methods and avoidance of secondary contamination of drinking water, combined with hygiene promotion, are required to prevent the population without access to safe drinking water from illness and death.

The simple act of washing hands with soap and water can reduce diarrhoeal disease transmission by one third [1]. Promotion of household-centred water treatment methods should therefore always be combined with hygiene training. Three key hygiene behaviours are of greatest benefit:

♦ Hand washing with soap (or ash or other aid)
♦ Safe disposal of faeces
♦ Safe water handling and storage [1].

Therefore, a combination of water treatment, safe water storage, health education and adequate sanitation is required to have a positive long lasting effect on public health.

In the past, governments in developing countries have invested much effort in the installation of sophisticated water treatment plants and public water supply systems especially in urban areas.

However, the conventional water treatment plants often fail to produce water safe for consumption. The lack of trained operators, reliable supply of chemicals and spare parts, as well as fi nancial constraints, often hinders a reliable operation and maintenance of the systems. Water shortages frequently lead to water supply interruptions and leaky distribution systems worsen the situation.

In addition, the rapid population growth in urban areas puts an excessive stress on the existing water and sanitation infrastructures and creates enormous problems in planning and constructing new infrastructure. Inhabitants of many urban centres in developing countries as well as the rural population therefore only have access to water of poor quality.

The treatment of water to be safe for consumption therefore often remains under the responsibility of the individual household. Options that rely solely on time- and resource-intensive centralised solutions will leave hundreds of millions of people without access to safe water, approaches to support the households in these efforts therefore should be promoted as [4].

The following water treatment methods for application at household level generally are recommended [5] to reduce faecal contamination of drinking water:

- Water storage at household level is a simple method to improve the water quality. Plain sedimentation however can only partly remove turbidity and faecal coliforms – the common indicator used to quantify the degree of faecal pollution. The main health risk associated with household water storage is the risk of recontamination through inappropriate handling practices.
- Boiling of water kills viral, parasitic and bacterial pathogens. The recommended boiling time is one minute at sea level, adding one minute for every additional 1000 meters in altitude. The main disadvantage of boiling water is the large amount of energy required thereby making it economically and environmentally unsustainable [6; 7].
- Water pasteurisation achieves the same effect as boiling at temperatures of only 70°C-75°C, but requires a longer exposure time of approximately 10 minutes.
- Water filtration by simple household filters, such as ceramic candle filters, stone and sand filters, will remove a high fraction of solid matter, but may not remove all the microorganisms. Commercially produced filters are relatively costly, and filters made of locally available material are generally of limited treatment efficiency with regard to microbiological water quality improvement.
- Water disinfection with chlorine is used to kill microorganisms (bacteria and viruses), but is not efficient enough to inactivate pathogenic parasites (e.g. Giardia, Cryptosporidium and helminthic eggs). This type of treatment requires the supply of chlorine either in liquid or powder form. Skilled application is necessary as chlorine is a hazardous and corrosive substance. Water treated by chlorine has a taste which many users do not appreciate.
- Solar water disinfection (SODIS) is a simple water treatment method using solar radiation (UV-A light and temperature) to destroy pathogenic bacteria and viruses present in the water. It's efficiency to kill Protozoa is dependent on the

water temperature reached during solar exposure and on the climatic and weather conditions. Microbiologically contaminated water is filled into transparent containers and exposed to full sunlight during 6 hours. Very turbid water with a turbidity of more than 30 NTU cannot be used for SODIS.

SODIS is a water treatment method that:

- Improves the microbiological quality of drinking water
- Does not change the taste of water,
- Is applicable at household level,
- Is simple in application,
- Relies on local resources and renewable energy,
- Is replicable with low investment costs.

2.1. Transmission of waterborne pathogens

Waterborne pathogens belong to the groups of bacteria, viruses and parasites. Although Viruses are often not detected in the water or the host, they may account for the largest group of causative agents, followed by parasites and bacteria's.

2.2. Characteristics of pathogens

Many common pathogens are not only transmitted through water but also follow other infectious pathways. Poor general hygiene practices often are a significant source of infection. Furthermore, secondary contamination of drinking water due to incorrect water handling is frequently observed in developing countries [8]. Therefore, interventions aiming at improving the water quality should always consider introducing general hygiene messages. Through such combined measures, significant positive health effects in the target population can be achieved.

The main factors influencing the health related relevance of pathogens transmitted through water are the pathogen's ability to survive in the environment and the number of pathogens necessary to infect a host (human) [9]. Well-known and widely distributed pathogens and their characteristics are listed in Table 1.

Table 1: Health significance and transmission route of water-borne pathogens

Pathogen	Health Significance	Transmission Routes	Persistence in water supplies	Infective Dose
Bacteria				
Campylobacter jejuni, C. Coli	High	- Person to person contact - Domestic contamination - Water contamination - Crop contamination	Moderate	Moderate
Pathogenic E.coli	High		Moderate	High
Salmonella typhi	High		Moderate	High
Other salmonellae	High		Long	High
Shigella spp.	High		Short	Moderate
Vibrio cholerae	High		Short	High
Yersinia enterocolitica	High		Long	High
Pseudomonas ae.	Moderate		May multiply	High (?)
Aeromonas spp!	Moderate		May multiply	High (?)
Viruses				
Adenovirus	High	- Person to person contact - Domestic contamination - Water contamination	?	Low
Polio Virus	High		?	Low
Hepatitis A Virus	High		?	Low
Hepatitis Non-A Virus	High		?	Low
Enterovirus	High		Long	Low
Norwalk Virus	High		?	Low
Norwalk-Like-Viruses (NLV)	Moderate		?	Low (?)
Rotavirus	High		?	Moderate
Protozoa				
Entamoeba hystolitica	High	- Person to person contact - Domestic contamination - Contamination through animals	Moderate	Low
Giardia spp.	High		Moderate	Low
Cryptosporidium spp.	High		Long	Low

[Source: 11,12]

The bacteria Vibrio cholera, Shigella, Salmonella and different pathogenic strains of E. coli are the most important water-borne pathogens. Gastrointestinal diseases caused by these bacteria's can be serious, and usually treatment is required.

Dehydration as a result of profuse diarrhoea is frequent among children under 5 years in the developing world [10]. Cholera epidemics are mainly caused by water borne Vibrio cholera. Therefore, water treatment is the most important measure for the prevention of cholera epidemics. Viral diseases are usually symptomatic and acute with relatively short disease periods, high viral shedding, low infectious dose and restricted host variety.

3. Proposed system

3.1. System Design

The main objective of this research is to develop a portable water purification system, which satisfy following conditions. The lab-prototype would be fabricated

- Easy to transport, assemble and install on poor transportation area by low-educated people
  - Most of material of the system would be easily obtainable on site, with low cost
  - If there are some parts which can't be easily obtained on site, it should be light weight, low volume, low cost so that it can be relatively easily transported to the site
- Can be operated outdoor condition
  - It should be operated without electric power grid or substantial fuel energy
  - If operational energy required, power consumption should be minimized
  - If operational energy required, it should be able to be powered by low cost (normal) battery, man power or renewable energy which can be easily accessible on site.

3.2. High credibility on sterilization

The system should be able to remove most of impurities in water. However, among the many other purification process, sterilization should be especially functions well just for in case of other filter mal-functions because of over-use

- The, water quality (sterilization result) would be tested and data analyzed
- Operation process protocol of the system would be developed

The research has 4 parts: designing and development of pre-filter; design and development of water sterilizer; converge the filter-sterilizer to make whole system; test the system in actual condition.

Carbon based charcoal filter with more site-practical design would be developed. This type of filter has been proven its performance and economic feasibility. However, improvement design can be developed for easier installation and usage.

Ozone-sterilizer is effective on killing bacteria and fungi in water. It is proven technology with various commercialized product. However, most of them are in form of in-house application form with relatively expensive cost. The new ozone generating sterilizer which is optimized for outdoor with minimal power and low cost would be developed and applied.

The filter and sterilizer would be assembled to make whole system and tested the performance. The water quality would be tested especially on measuring the content of micro-organism.

4. Discussion and findings

After actual perormance test of the newly developed water purification system, the prototype can be used to make mass-supplied water filtration system. The system can be supplied to the area of flood disaster area to provide drinking water to the residents.

4.1. Advantages of the system

- New portable water source can be developed for disaster event, such as flood
- The water source can be also used for remote resident people or military who cannot access to clean potable water easily.
- By mass producing and stockpiling the system, developed from the current project, portable water supply can be more secured in case of natural disaster or emergency

5. Conclusion

In conclusion, sterilization is one of the most important factors in flood situation, since water borne infection frequently epidemics on flood and after-flood. Therefore, it is required to develop certain water purification system with highly reliable sterilization even with overused filters. Ozone is effective for water sterilization. However, few commercial ozone sterilizers are applicable to be used in outdoor, emergency cases. Therefore, through this project, we are going to develop converged system of traditional low cost filter and ozone sterilizer, so that it can be used as low cost, highly reliable water purification system which can be used for emergency case, such as flood. Once the prototype developed, mass-supply of the system could be delivered to the flood victims in future. The development can be done by collaborative effort between Malaysia and Korea.

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