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Rainwater Harvesting: Sustainable Behavior for Collective Well-Being and Environmental Sustainability

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ABSTRACT

The water crisis happens almost all over the world and has become a global crisis that must be handled by every country. Annual disasters that always occur in Indonesia and other tropical countries in general are drought during the dry season, floods and landslides during the rainy season. The phenomenon of climate change, extreme climates, rainfall and all flood control facilities are the variables most often used as discussion issues. Areas affected by drought will receive water distribution rations from the government and/or various parties through social service activities. These recurring disasters tend to be addressed pragmatically based on the condition of immediate needs. This situation continues every year until today, so we are actually trapped in a multiple disaster cycle. The important real action that must be taken is to explore methods to encourage active participation in activities that have a positive impact on the environment, starting with changes in sustainable behavior patterns. Changing people's behavior patterns is at the core of promoting sustainable development. During the rainy season it collects as much rainwater as possible, then the rainwater is treated through a water electrolysis process (ionization process) into low pH water (acidic, has an antiseptic and anti-bacterial function) and high pH water (alkaline, healthy drinking water). Every member of the community plays an active role in processing rainwater independently, has access to free and healthy drinking water, builds a healthy lifestyle, besides that there will be more reserves of groundwater available in the dry season. Rainwater harvesting (collecting, processing, harvesting) is eco-literation educational programs based on healthier, more positive and constructive sustainable behavior for collective well-being and the environment sustainability.

Keywords: *collective wellbeing; environmental sustainability;rainwater harvesting; sustainable behavior.*

Introduction

The United Nations was currently preparing to adopt a sustainable development agenda by September of 2015, in line with World Water Day celebration (annually on March 22) that highlights the importance of freshwater, advocating for the sustainable management of freshwater resources, the essential and interconnected role of water. Water, a key element for public health, is essential for food and energy, security and supports the functioning of industries (https://www.thejakartapost.com/news/2015/03/25/coping-with-water-scarcity-indonesia.html).

The water crisis happens almost all over the world and has become a global crisis that must be handled by every country https://www.statista.com/chart/26140/water-stress-projections-global/.

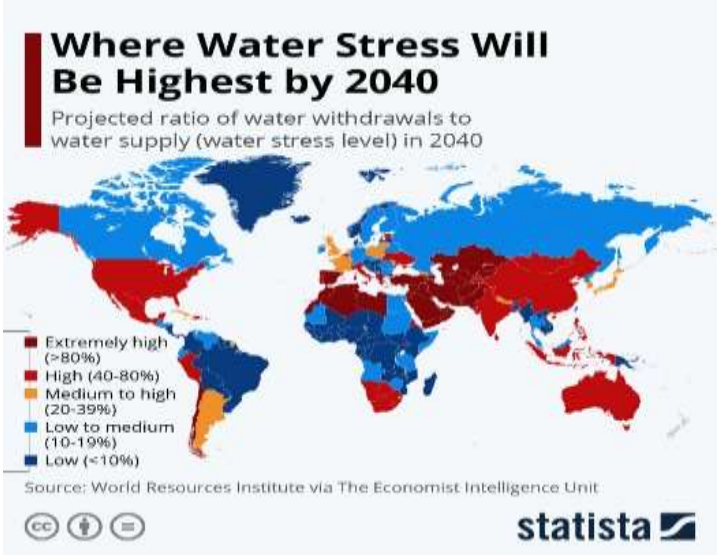

Figure 1: water stress
Source: https://www.statista.com/chart/26140/water-stress-projections-global/

Indonesia's water resources currently need exceptional attention from the government. Today's water resources have a higher level of complexity compared to that when the regulation was first introduced. While scarcity of fresh water hits many areas in Indonesia, we also witness chronic mismanagement of water resources, with several parties overusing it and others using it for activities that pollute water. In fact, water resources in Indonesia represent nearly six percent of the world's water resources and about 21 percent of total water resources in the Asia-Pacific region, or more than two trillion cubic meters of natural renewable water per year. So, statistically speaking, Indonesia is not a water-scarce nation. However, the availability of more than the above-mentioned amount of natural renewable water has its own challenge as the water resources are unequally distributed among the islands and the availability is not parallel with population distribution. Java has less than 10 percent of the country's water, whereas more than 140 million people live on the island, nearly 60 percent of the country's population. Kalimantan has 30 percent of Indonesia's water and only inhabited by six percent of Indonesia's population. With Java being most heavily populated but having a small percentage of the country's water, the island is predicted to face a clean water crisis. The 2015 estimation by Robert Wahyudi Triweko, an expert on engineering and the management of water resources, disclosed that water demand on Java reached 164.672 million cubic meters per year, while the availability of water was only 30.569 million cubic meters per year, leaving a big deficit gap of 134.103 million cubic meters per year. The renewable water is surface water, but this is often highly polluted and leads households and industry to consume more groundwater. This mostly happen in big cities where dependency on groundwater is widespread. As Indonesia's population continues to grow and its industries develop, improvements in water management and related infrastructure are important for future economic success. Water shortages are expected to be a constraint to Indonesia's economic growth potential (https://www.thejakartapost.com/news/2015/03/25/coping-with-water-scarcity-indonesia.html).

Water resources have become the most prominent aspect for human beings to live. What if some areas experience water scarcity? How would they live? About 18 million Indonesians lack access to safe water and 20 million lack access to improved sanitation. For many families, water sources are distant, contaminated or expensive, and household sanitation is unaffordable

(https://water.org/our-impact/where-we-work/indonesia/). According to Professor of Faculty of Engineering UGM, Prof. Dr. Ir. KMT. Sunjoto Kusumosanyoto, Dipl. HE. DEA, lack of water resources has happened to Indonesia, such as Java, Bali, and Nusa Tenggara. These areas have difficulties suffice their water needs, approximately around 1.500-2.000 liter per day per capita. The water needs in this context refer to human consumption, including agriculture and farming as food resources (https://ugm.ac.id/en/news/20916-water-scarcity-in-some-areas-in-indonesia/).

During the dry season, some areas lack water to the point where they experience drought because the quantity of groundwater is decreasing, the quality of groundwater is decreasing, springs are getting less water discharge or river water is getting dirtier and experiencing siltation. Some people are forced to buy clean water to meet their daily clean water needs. Farmers also incur additional costs for renting water pumps and buying diesel fuel to irrigate their fields (https://bpbd.bogorkab.go.id/487-juta-jiwa-penduduk-terdampak-kekeringan-yang-tersebar-di-4-053-desa/). Drought is mostly caused by disturbances to the hydrological balance, such as degradation of river flow which changes its function which causes disruption of the groundwater infiltration system and siltation of reservoirs or water reservoirs which causes their capacity to decrease (Lestari & Pamuji, 2018 https://doi.org/10.24912/jmstkik.v1i2.988). This condition will get worse during the long dry season, resulting in the emergence of waterborne diseases such as cholera, typhus, skin diseases, digestive tract, and others (Indriatmoko & Raharjo, 2015 https://www.neliti.com/publications/245632/kajian-pendahuluan-sistem-pemanfaatan-air-hujan).

Short-term countermeasures can be carried out by dropping clean water when the water sources in settlements have begun to decrease. Dropping of clean water is carried out as long as the drought continues until the water source returns to normal. For medium-term countermeasures, construction of dug wells, deep groundwater wells and rainwater harvesting can be carried out. In addition, research can also be carried out in order to look for other potential water sources. As for long-term countermeasures, this includes reforestation around springs and construction of a Water Management Installation (https://perkim.id/kebencanaan/permukiman-tangguh-bencana-di-daerah-rawan-kekeringan/). Therefore during the rainy season many areas experience floods and landslides, this is an irony.

Figure 2: photo illustration of flooding in the rainy season and drought in the dry season

During the long dry season, people who have adequate financial capacity are used to being prepared to buy clean water, while people with weak financial means are lulled by the habit of waiting/expecting/relying on water distribution rations from the government and/or various parties through social service activities.

Figure 3: photo illustration of distribution of clean water in the dry season

There are various ways to address the problem when floods and droughts often occur, some solutions do not have a significant long-term impact, such as the emergence of clean water buying and selling activities and water donations for underprivileged communities during the dry season. This situation continues until now, disasters tend to be addressed pragmatically by the community to meet temporary needs. the psychological effect is a pattern of dependency on help and instant behavior habits, meanwhile the long-term problem of this water problem has actually not been completely resolved. Patterns of behavior that pay little attention to environmental sustainability and follow-up that are momentary in nature occur repeatedly and continuously, in fact we are already trapped in a cycle of multiple disasters, namely natural disasters and social disasters. Therefore, efforts are needed that are sustainable in the long term while taking into account the needs of the wider community as well as environmental sustainability.

Rainwater harvesting as an alternative solution

Simple countermeasures that can be made independently in residential areas are rainwater harvesting as the solution to the mitigation of this multiple disaster. Rain water harvesting has been widely implemented in several countries, such as Taiwan, Uganda and Sri Lanka. For its application in Indonesia it is not yet popular because it is not widely known even though the system is simple. Semarang is one of the cities that has successfully implemented rain water harvesting. There are 8 sub-districts that have implemented rain water harvesting at sub-district offices, mosques and schools. The technology used to overcome drought was provided by the Semarang City Environment Service. The hope is that these countermeasures can reduce the use of groundwater (https://perkim.id/kebencanaan/permukiman-tangguh-bencana-di-daerah-rawan-kekeringan/). Rainwater harvesting is not something new in human civilization. This rainwater harvesting effort is one of the conservation efforts to maintain an adequacy of water supply in urban areas. Schools as one of the large infrastructures spread across an area have great potential to be used as a rainwater harvesting facility. Rainwater harvesting activities can also be used as an educational tool in the context of conserving water resources in schools (Rofil & Maryono, 2017 https://jurnal.uns.ac.id/prosbi/article/view/17790).

The basic ideas of the rainwater harvesting are 1) changing the stigma of rainwater into a gift and sustenance from God that can be used for the benefit of many people, 2) changing the orientation of pragmatic short-term interests to mid-term until long-term interests that are sustainable, 3) preserving the environment, especially conserving groundwater. Rainwater harvesting has three main benefits, namely first, contributing to the independent supply of clean water to meet routine daily needs, including drinking, cooking, washing clothes, caring for

livestock and crops. Second, this action can be interpreted as an act of giving rainwater alms to replenish/renew the quality and quantity of groundwater. Third, this action contributes to flood and landslide disaster risk management because the community will consciously plant trees to save (= store) rainwater.

Rainwater harvesting also has religious value because humans are consciously grateful for the sustenance from Allah SWT and actively distribute it for the welfare of the whole nature (collective well-being). Rain is proof of Allah SWT's power to create and sustain all creatures on earth, so there is no doubt for Moslems to be grateful for rain as a blessing from Allah SWT. Rainwater is a blessing given to all living things in the world from God Almighty. As several verses in the Al-Quran explain, "Have you not noticed that Allah sends down rainwater from the sky as a source on earth ..." (QS. Az Zumar 39:21). It is He (Allah), Who has sent down rainwater from the sky for you, some of it becomes drink and some of it fertilizes the plants, where you graze your livestock (QS An-Nahl 10).

A very potential provider of water sources is abundant rainwater, but changes in land use of an area also lead to reduced green open land, reduced natural rainwater absorption zones so that when it rains the rainwater will quickly turn into runoff water. On the other hand, most people respond to rainwater according to inaccurate knowledge and information. Public perceptions about rainwater in general are 1) causes of flooding, it is proven that every time it rains it always floods in several areas, t2) he cause of illness, so that after the rain will experience health problems, 3) acidic, so it is harmful to health (especially skin) and 4) dirty, so not fit for consumption.

Empirical evidence

The following table 1 shows the results of measuring the pH & TDS of rainwater from gutter outlets at UPT Balai Yasa Jogjakarta in 2018:

Table 1. PH & TDS of rainwater from gutter outlets at UPT Balai Yasa Jogjakarta

Parameter	Unit	Section										Minister of Health regulations no. 32, 2017
		Control	Production (north side)	Production (east side)	Production (south side)	Office (west side)	Office (east side)	Washing	Painting shop (north side)	Painting shop (south side)	Final test	
pH		7,4	7,3	7	7,1	7,5	7	7,2	7,9	7	7,4	6,5 – 8,5
TDS	ppm	12,5	10,1	8,4	8,6	15,8	10,6	11,4	18,7	6,9	5,9	1.000

pH (potential/power of Hydrogen)
TDS (Total Dissolved Solid)
ppm (part per million)

Based on the measurement results in the table above, it can be concluded that rainwater has a neutral pH and low TDS, it is safe for consumption.

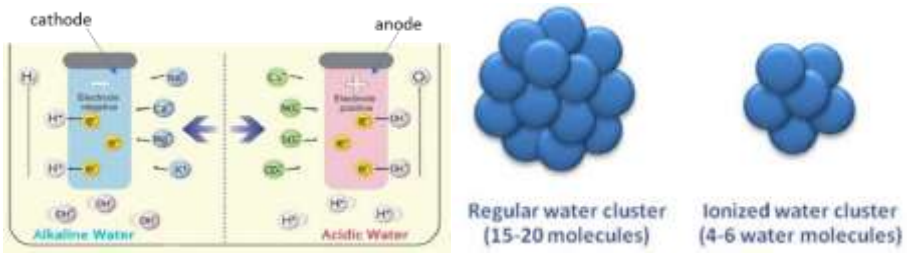

Figure 4: water electrolysis process

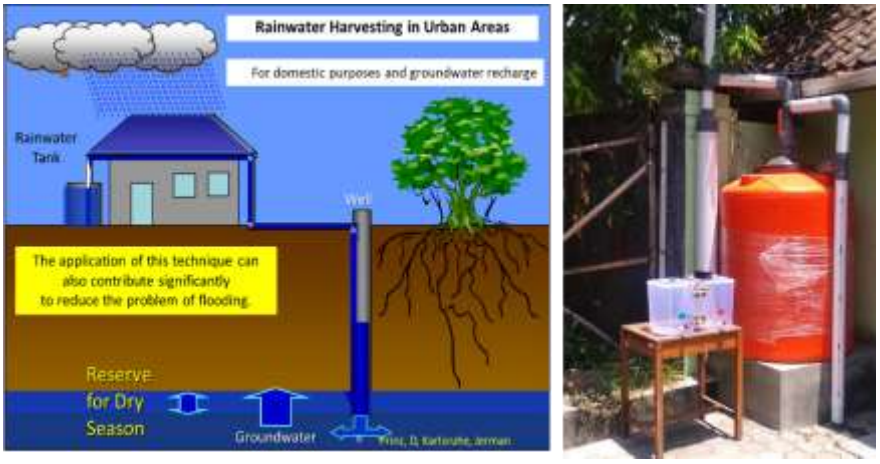

Figure 5: rainwater storage installation

The output of the water electrolysis process for at least 12 hours are electrolyzed oxidizing water (low pH water, acidic) and electrolyzed reducing water (high pH water, alkaline). Strongly acidic electrolyzed oxidizing water (EOW) showed remarkably high bactericidal activity against all four bacterial strains (*Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa*) including a spore-forming bacterium, *B. subtilis*. Strongly alkaline electrolyzed reducing water (ERW) exhibited high bactericidal activity against gram-negative bacteria (*E. coli* and *P. aeruginosa*). It was also suggested that electrolyzed water can be utilized in cosmetics and pharmaceutical products in single or simultaneous use with existing disinfectants or antiseptic. In addition, most electrolyzed waters show little skin irritation; thus these electrolyzed waters could be utilized in antiseptics or preservatives (https://www.jstage.jst.go.jp/article/sccj/43/2/43_2_101/_article). Electrolyzed oxidizing (EO) water has been regarded as a new sanitizer in recent years. EO water have the following advantages over other traditional cleaning agents: effective disinfection, easy operation, relatively inexpensive, and environmentally friendly. The main advantage of EO water is its safety. EO water which is also a strong acid, is different to hydrochloric acid or sulfuric acid in that it is not corrosive to skin, mucous membrane, or organic material. Electrolyzed water has been tested and used as a disinfectant in the food industry and other applications. Combination of EO water and other measures are also possible. This review includes a brief overview of issues related to the electrolyzed water and its effective cleaning of food surfaces in food processing plants and the cleaning of animal products and

fresh produce (https://www.sciencedirect.com/science/article/abs/pii/S0956713507001697). The following table shows an estimated calculation of the cost of drinking water for each person per year:

description	quantity	unit
the need for drinking water per person/day	2-3*	liter
Number of days/year	365	day
Price of drinking water	Rp1.000**	liter
Total cost of drinking water expenditures	Rp1.095.000	person/year

*The Ministry of Health of the Republic of Indonesia (Directorate of Prevention and Control of Non-Communicable Diseases) https://p2ptm.kemkes.go.id/preview/infografhic/berapa-takaran-normal-air-agar- tidak-kekurangan-cairan-dalam-tubuh#:~:text=Pada%20orang%20dewasa%2C%20konsumsi%20air,pada%20tubuh%20yaitu%20sekitar%2020%25

** based on the average price of bottled mineral water per liter as of June 2023 Based on the table above, cost savings can be calculated on drinking water consumption per person per year.

Method

Develop educational materials on knowledge about rainwater and rainwater harvesting. a) Cognitive aspect: knowledge of TDS and pH of rainwater, knowledge of rainwater harvesting management, knowledge about the conservation of groundwater resources. b) Economic aspect: calculate the estimated need for drinking water and the cost of purchasing drinking water per person per year, comparison of the estimated cost of spending on drinking water before and after rainwater harvesting installations. c) Health aspect: knowledge about the benefits of electrolyzed oxidizing water (low pH, acidic) and electrolyzed reducing water (high pH, alkaline). d) Spiritual aspect: exposure to verses in the Al Quran which contain the benefits of rainwater.

Provide education to the public about rainwater and rainwater harvesting. a) demonstrate how to use pH meter and TDS meter. b) demonstrate the difference test of pH & TDS of ground water, PDAM water and rain water

Provide training to the public about rainwater and rainwater harvesting. a) soft skill training on mindset change. b) training of assembling rainwater storage installations. c) training of a simple, efficient and effective water electrolysis equipment

Discussion

Program benefits and expected outcomes

The benefits of the rainwater harvesting program are 1) new knowledge about rainwater and rainwater harvesting, 2) stimulate the active role in disaster mitigation (drought, floods and landslides) and 3) building self-sufficiency in clean and healthy water.

It is hoped that rainwater harvesting will become a new sustainable behavior pattern that has a positive impact on social change, collective well-being and a healthier environment.

Sustainable behavior and collective well-being

It is important to change behavior pattern that is harmful to the environment and explore methods to encourage increased involvement in activities that protect the environment (Zhao, et.al, 2018 https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02367/full). Changing people's behavior patterns is a core aspect of promoting sustainable behavior. It is clear that research in behavioral science has an important role to play (Moreira, et.al, 2020 http://dx.doi.org/10.1027/1015-5759/). Individuals that engage in pro-ecological and frugal actions are also likely to practice altruistic and equitable behaviors. Thus, a person that practices sustainable behavior not only engages in one kind of actions but tends to act in an integrated pro-environmentally manner. In addition, our measure of sustainable behavior was significantly and directly influenced by intention to act, repeating a result from the literature on predictors of pro-environmental behavior and indirectly predicted by environmental emotions and affinity towards diversity. The sustainable

behavior factor also correlated significantly (yet, slightly) with a measure of happiness (Fonlem, et.al, 2013 https://doi:10.3390/su5020711).

The health and quality of life of a community may be improved by focusing efforts on community characteristics that support key aspects of collective well-being (vitality, opportunity, connectedness, contribution, and inspiration) (Roy, et.al, 2018 https://pubmed.ncbi.nlm.nih.gov/30079743/). As in most areas of psychology, a negative bias permeates the study of the subject of conservation psychology: sustainable behavior (SB). SB constitutes the set of actions aimed at protecting the socio-physical environment. This behavior is sometimes addressed as having negative antecedent-instigators (fear, guilt, shame), activated to avoid undesirable outcomes from environmental degradation. Also, psycho-environmental researchers often visualize negative psychological consequences (discomfort, inconvenience, sacrifice) of SB. Yet, a number of studies reveal that positive psychological antecedents (capacities, emotions, virtues and strengths) as well as positive psychological consequences (satisfaction, psychological well-being, and happiness) of SB are also significant determinants of pro-environmental actions (Verdugo, 2012 https://link.springer.com/article/10.1007/s10668-012-9346-8).

Conclusion

Rainwater harvesting (collecting, processing, harvesting) is eco-literation educational programs based on healthier, more positive and constructive sustainable behavior for collective well-being and the environment sustainability

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