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Indonesia: Water and Sanitation

Indonesia: Duckweed (*Lemna*) as a Part of Sustainable Water Treatment

As a geological wonder**,** comprising hundreds of volcanoes and thousands of islands, Indonesia takes rank as the largest country in Southeast Asia. Boasting a booming population of over 264 million people, it is the fourth most populous country in the world and the epitome of economic development. However, as Indonesia's bustling capital continues to expand as an economic epicenter, communities struggle in terms of contaminated water sources and limited access to sanitation facilities, affecting multiple facets of life including food security, development and education. About 24 million Indonesians lack safe water and over 40 million have insufficient access to an improved water source [1]. Water issues relate to discoloring, distaste and odor from factors such as soil, iron and chemical contamination [4]. Despite the moderate progress being made to reduce these contaminants, the provision of clean water has not yet reached a development priority, specifically at the highest government level. The local governments that received control over water sanitation and supply have since failed to ameliorate unsatisfactory drinking water conditions, particularly because the transfer of responsibilities lacked the proper funding needed to do so. The solution to this issue takes the form of the world's smallest flowering plant: duckweed (*Lemna*). Current government and organizational actions related to expanding clean water delivery and sanitation infrastructure should integrate duckweed wastewater treatment systems as a sustainable and efficient way to reduce pollution in bodies of water without overwhelming current treatment facilities. This would meet the needs of urban and rural communities, especially impoverished households that cannot afford or are not close to piping water facilities.

Over the past few years, a prospering economy in Indonesia has led to a rapid decrease in the unemployment rate [8]. While employment has been steadily declining in the agricultural sector in recent years, it still accounts for the largest proportion of jobs in Indonesia. As of 2020, the agricultural sector employs about 28% of the workers in Indonesia, serving as the lowest paying sector with employees earning 2.06 million Indonesian rupiah monthly. Rice production dominates and small family farms are the predominant type. The family may be nuclear, such as those in Java, or extended such as those in West Sumatra. There is a reliance on the yield of the agricultural sector to feed the Indonesian population and stimulate the economy. In contrast, Indonesian employees in the mining and excavation industry, the highest-paying sector, earn an average monthly net wage of 5.1 million Indonesian rupiah [8]. Compared to past years, Indonesians workers have higher education qualifications in the labour market. But, deficits in productivity, quality, gender, and disparities across the provinces remain [11]. Data has shown that even though primary school enrollment has reached 95%, many students are still absent because of health problems arising from unclean water sources. Access to safe water can improve short and long term measures of education outcomes [14].

Rural communities, especially those in remote islands and near bodies of water that may have saltwater intrusion and face pollution from nearby factories, landfills, or older mining grounds, suffer from access to safe drinking water [4]. This is partly due to distribution issues as delivery of piped water to rural and remote areas is difficult. Indonesia is a large archipelago with many villages across the over 17,500 islands governed under 514 local governments with different cultures, and levels of resources, economic capabilities and sanitation infrastructures [3]. Since piped water remains low (with only 17 % of population receiving and around 77 % of those receiving being in urban households), households will resort to other sources of drinking water like wells, lakes, rainwater and rivers which tend to be lower

quality and/or will need to travel very long distances to fetch it [10]. There is a large disparity in rural versus urban lifestyles when it comes to access to healthcare, hospitals and education that play a role in clean water accessibility. Rural households tend to lack a complete formal education and need to travel longer distances to reach hospitals in order to access medical resources. Surveys show that the majority of respondents find the implementation of the Jaminan Kesehatan Nasional, a single-payer health insurance system passed in 2014, a better health service than earlier years. However, the policy is still not entirely based on the needs and priorities of the citizens [7].

While there has been improvements and progress over the past decade, around 26% of the population still doesn't have access to safe and sustainable water. In 2018, 82% of the urban population had access to safe drinking water whereas only 64% of the rural population did [10]. 56 % of the country's population lives in cities and increasing urbanization is highlighting the lack of adequate wastewater management in these areas. For example in the capital of Indonesia, Jakarta, only 2% of the population of over 10 million is connected to the public sewage system while most urban households have septic tanks that leak. So the sewage passing through isn't always sent to the treatment plants and ends up flowing onto the ground. 95 % of Indonesia's wastewater runs off into agricultural fields, rivers, and open drains [2]. The result is that poor groundwater, sanitation issues coming from open defecation and lack of proper toilet facilities and poor hygiene practices contribute to various public health and environmental issues. One effect is high infant mortality "(212 per 1000 births compared to 59 per 1000 in other middle-income countries in SouthEast Asia)" stemming from fecal borne diseases such as diarrhea and typhoid [2]. Another effect is ecosystem pollution. Indonesia's tropical climate is characterized by heavy rainfall, especially from November to March, with an annual average of 70–125 inches in lowland areas. Nutrients from storm runoff, most notably nitrogen and phosphorus, enter streams and lakes from fertilizers, industrial waste and other sources. Eventually, these mineral nutrients will build up in the water and encourage the growth of algae and water plants, reducing light penetration. As they decay, bodies of water will suffer from severe oxygen depletion, consequently killing fish adapted to aquatic environments with high oxygen levels. These eutrophic ponds and lakes can be harmful to fish as the toxins accumulated when they feed upon the algae will be consumed by predator fish. Furthermore, pesticides and heavy metals are polluting waterways and entering the food chain through fish, which can have negative health effects on humans that consume them [5]. Climate change is also impacting the agricultural sector. Rainfall pattern changes, increase in frequency and intensity of extreme weather events, rising overall temperatures and sea level rises affect the planting season and fisheries in coastal areas. The negative impacts include shifts in planting and harvesting times, changes in crop productivity and salinization of aquifers putting pressure on an already vulnerable water treatment system. These facts are especially critical as it affects Indonesian livelihoods. A typical meal for families consists of rice as the staple with soup and vegetables, as well as a side dish of fish or meat. As a country surrounded by islands, marine fish and seafood are abundant and popular amongst Indonesian residents, especially in eastern regions where most residents work as fishermen. As the staple food, rice is considered the most prominent food crop in Indonesia, accounting for 30% of total agricultural land and grown by about 77% of farmers in the country.

Between 2006 and 2018, the PAMSIMAS (Penyediaan Air Minum dan Sanitasi Berbasis Masyarakat or Community Based Drinking Water Supply and Sanitation) program, a collaboration between local communities and governments, scaled up the delivery of water and sanitation services. They have reached 22,961 villages and have improved water facilities for 17.2 million people. They have also developed better hygiene approaches by adopting handwashing programs and reducing open defecation actions. Over 1,650 villages adopted disability inclusive designs for their public facilities as well [3]. However, impoverished and low income households in both urban and rural communities still struggle with affordability of these cleaner water resources even if a water network is available near the households [14]. Two thirds of water supplies are derived from increasingly polluted urban and industrial surface

waters in cities. Groundwater is being over extracted in many coastal cities so the lower parts of most rivers are already polluted beyond capacity of existing water treatment plants [15]. So, while governments can upgrade plants to be able to handle a larger inflow of pollutants in the water, it is an expensive solution that will only strain citizens' pockets. Pollution levels exceed treatment capacity so a more sustainable solution would be to clean up the source. This approach would be to implement a variety of strategies simultaneously including continuing to reduce erosion and runoff, increasing education on better environmental practices and using duckweed to clean up waters.

Duckweed are aquatic and ubiquitous plants that are easy to grow indoors as a result of their size and are adapted to a wide variety of geographic and climatic zones. A large number of duckweeds are found in moderate climates of tropical and temperate zones, spread by floods and aquatic birds[13]. Individual duckweed plants are composed of a single, flat oval leaf no more than ¼ of an inch long that floats on the surface of still-moving ponds and lakes [12]. Even with their miniscule size, duckweed flowers can attract organisms like bees or flies, that can spread the plants pollen after being attracted by secretions from the stigma. Most significantly, duckweeds can reproduce asexually through the formation of chains of new stems from vegatative buds [12]. Their cycle of reproduction allows duckweeds to have a rapid growth rate and production of new offshoots, which is extremely beneficial to farmers looking to utilize its high protein content and ability to clean wastewater, especially useful in rural areas. In urban areas, duckweed-based systems can act as the first step in the treatment process to reduce the load on treatment plants taking up heavily polluted waters.

Duckweed-based wastewater treatment systems are basically lagoon systems that support the growth of duckweed. They are simpler in design and more efficient than conventional wastewater treatment, making them a more attainable system of treatment in rural communities. This is because they actively remove nutrients from the wastewater systems and suppress algae growth which account for the high level of suspended solids in typical lagoon system effluent [13]. Duckweed nutrient removal rates are directly proportional to their growth rate, as they convert minerals and nutrients in the water column into plant tissue as they grow. As a result, treated sewage from duckweed-based treatment systems contain less nitrogen, phosphorus, calcium, chloride ions and organic compounds/human enteric pathogens because duckweed species bioaccumulate as much as 99% of nutrients in wastewater [13].

Results of pilot operations in South Asia (notably Bangladesh) and Latin America suggest that duckweed would not only be important as a source of fish and poultry feed but also as a wastewater treatment process [13]. The duckweed-based wastewater treatment would first and foremost need to be implemented with consideration to the cultural values, behaviors and receptiveness of the people living in the communities. In Indonesia, intensive cultivation processes in the past and present have grown and changed in response to the need of feeding a large population with limited available resources including excreta, so in this country duckweed farming would likely be socially accepted [16]. Behaviors like current polluting and hygiene practices would need to be considered. Next, a baseline survey of the land should be performed where aspects like water bodies, water availability, nutrient source, labor resources, domestic animals and current existing farming systems are evaluated [16]. Community involvement is crucial so there needs to be large campaign programs to develop a sense of public belonging and participation as well as to raise awareness across many stakeholders. Community members will provide critical information on their needs and preferences, like the ideal location of duckweed farms so that they

don’t negatively interfere with other local practices. Members can also be trained partially or full time by experts to be employed themselves in managing the treatment system. PAMSIMAS should continue their current efforts in mobilizing local governments and communities in making clean water more accessible while also incorporating duckweed water treatments in their planning and management. It is critical for local governments and organizations to be as involved in the funding and management as possible so that they are self-sustaining. The Ministry of Health in Indonesia is responsible for water quality related aspects so therefore they will be a part of heading the process. For the past few years, Water.org, an American nonprofit developmental aid organization has been working to increase access to water and sanitation for low-income households. By pursuing partnerships with different types of organizations, including non-governmental organizations like CARE International as well as the Ministry of Health they will be able implement duckweed water sanitation initiatives with more ease. Using a report commissioned by The World Bank which documents the successful planning and implementation of duckweed farming in Bangladesh as a guide [17], similar steps can be applied to Indonesia. The Ministry of National Development Planning Agency (Bappenas) which has planned investments in Indonesia can partner with the World Bank, who have supported and been involved in previous projects with duckweed and water sanitation through a number of donation and investment projects [16, 17]. Regarding relations between local and international donors and other stakeholders, the National Water Supply and Environmental Sanitation Working Group (Pokja AMPL) will be able to coordinate these connections. With the combined effort and commitment of these organizations, in time duckweed water treatment systems can be successfully implemented. Access to clean and affordable water is a human right and working to make it safely and affordably accessible can dramatically improve health, development and educational outcomes in Indonesia.

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