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The Impact of the Environment and People's Attitudes on Greywater Management in Slum Coastal Settlements

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Abstract

The rapid population growth in many countries will ultimately impact the provision of essential services and engender many challenges, such as inadequate sanitation. Indonesia has an extensive coastline and densely populated coastal areas that have grown sporadically, creating slums. These areas have long been associated with poor greywater management. Greywater is dumped into beaches, roads, and yards without pre-treatment, thus harming the environment and society. This study aims to identify various factors influencing community actions to manage and overcome greywater-related problems in coastal slum areas. Using methods by combining qualitative and quantitative approaches. The influential factors in the physical condition of the built environment, the natural environment, community activities, and government involvement related to greywater were analyzed qualitatively, while the public understanding of greywater management was assessed quantitatively. The results showed that these four factors significantly influenced people's attitudes towards wastewater treatment. The findings show that these four factors affect people's mind-set about handling greywater, which becomes an obstacle to changing their attitudes and views on greywater. The four factors have the same level and cannot be separated in dealing with greywater. Treatment strategies are in accordance with coastal nature, settlements physical conditions and communities are then chosen Treatment Horizontal Flow.

Keywords: Drainage; Greywater Management; Dirty Water; Slum Coastal Settlement; People Attitude; Perception.

1. Introduction

The rapid population growth in some countries impacts waste management issues and basic service provision, such as inadequate sanitation [1]. According to the Centers for Disease Control and Prevention (CDC) [2], 3.6 billion people do not have access to safely managed sanitation at home; 1.9 billion of them have access to basic sanitation; and 494 million practice open defecation. According to the water project [3], children in developing countries bear 88% of the burden caused by unsafe water supply, sanitation, and hygiene [4].

Because most human activities that use water produce wastewater, known as greywater, from bathtubs, showers, hand basins, washing machines, dishwashers, laundries, and kitchen sinks [5, 6], liquid waste disposal is one of the problems that frequently arise in developing countries as a result of human activities. In waste management, there are different treatments between high, middle, and low-income countries, and based on data from UNESCO [7], on average high-income countries treat about 70% of the municipal and industrial wastewater produced, and 38% in upper-middle-income countries, and 28% in lower-middle-income countries. Only 8% of wastewater in low-income countries is treated, globally, more than 80% of all wastewater is discharged without treatment. Greywater can account for up to 100-150 L/PE/day in Europe and high-income countries, with lower volumes in low-income countries [8]. Because only

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the more polluted fraction of domestic wastewater is sent to the treatment plant [9-11], source separation of greywater can reduce the waste volume sent to wastewater treatment plants and the energy required for their treatment [12]. Later, it is frequently dumped onto roads or open spaces, causing harm to public health and the local economy [13].

Indonesia's wastewater management is still in its early stages. According to the Central Statistics Agency's 2007 National Socio-Economic Survey, 67% of the rural population already has access to basic sanitation. However, sanitation and wastewater treatment quality remain inadequate [14], with Indonesia remaining the G2O's second- worst sanitation country after India. The worst sanitation problem in Indonesia is open defecation, which is still prevalent. Sanitation is still a problem worldwide [15], and the world is falling dangerously short of its goal of providing sanitation to all by 2030 [16]. With a 270 million population, domestic wastewater is one of the major contributors to wastewater generated from human activities. Overall, greywater quantity in Indonesia is 1 to 4 times higher than black water quantity, while the quantity of untreated greywater was 3 to 6 times higher than untreated black water [17].

One of the most significant challenges associated with the growth of informal (slum) settlements in developing countries is the production of wastewater [7]. Currently, approximately 1 billion people live in slums or squatter camps. According to UN-HABITAT data [18], if significant interventions to improve access to water, sanitation, secure tenure, and adequate housing are not implemented, this number could rise to 1.5 billion by 2020 and even 2 billion by 2030. According to citywide case studies, 30–50% of the urban population lives in informal settlements on riverbanks, floodplains, coastal areas, hillsides, or next to landfills. Residents choose these locations because they are less likely to be evicted. After all, the land is not particularly appealing to developers. People living in informal settlements face destitution, high density, pollution, a high illiteracy rate, and insecurity, making these areas vulnerable to violence and crime [18]. The structural quality of informal housing arrangements and configurations is poor. As a result, most informal settlements are vulnerable to natural disasters [19].

Slums are partly located along coastlines, and approximately three billion people, or roughly half of the world's population, live within 200 km of coastlines. Most are expected to live within 60 to 200 km of the coast by 2025. The average population density in coastal areas is about 80 people per square kilometer, which is double the global average [1]. In general, fishing villages in rural areas meet these criteria for slums. Karama village is one of the settlements. Without good management, the greywater network condition is minimal in places and occurs naturally.

This research is vital because there has never been a study that has previously explained the influence of 4 condition settings (physical settings, natural settings, demographics, and government) on people's behavior in treating greywater in coastal slums. Previous research discussed three main things, namely greywater treatment, greywater content, and greywater impacts. Several studies on the processing and utilization of greywater address filtration techniques regulated by gravity and disinfection for household use [20] and double filtration greywater processing in slum areas [21] research on greywater content includes greywater content in households [22, 23], characterization and pollutant loads of Greywater in urban slums [24], specification and treatment of domestic wastewater [17], and greywater treatment strategy based on a local on-site greywater treatment system in households or the so-called 'autonomous water management [25]. The applied greywater treatment technologies in households efficiently render Greywater for agricultural uses in adequate volumes [26]. Additionally, there are studies concerned with greywater compromising the biological quality of soil and vegetable crops [27], public health [28], the physical and mechanical properties of soil [29], and the impact of powder detergent water on shrinkage cracks of soil due to drying [30].

This research identifies the factors influencing the public attitude toward greywater management and efforts to address coastal slums.

2. Materials and Methods

Here, we employed mixed-use methods by combining qualitative and quantitative approaches. The physical conditions of the environment (both natural and built environment) and people's daily activities related to greywater disposal in residential units, public areas, and other sources in settlements were investigated qualitatively. The behavior or dominant practices in disposing of greywater and the reasons for these practices were studied quantitatively by distributing questionnaires. The dependent variable was greywater, and the independent variable was the environmental impact and community behavior. The independent variables to study the environmental impact included physical, natural, demographic, and government involvement. Meanwhile, the independent sub-variables for community behavior were daily activities related to greywater and the reasons for performing such behaviour.

2.1. Data Collection

The residents of Karama village participated in this study. The required data were collected by administrating a closed questionnaire. The subjects were selected using accidental sampling by submitting a questionnaire to anyone present at the study's time without prior determination. As the samples were directly met on-site, the exact number of participants could not be estimated. Therefore, the number of samples was limited using the incidental sampling method, which uses calculations from the Linear Time Function (LTF) formula, namely the sample number according to time estimates [31]. The number of samples determined by the best time to conduct and carry out research can be expressed as in Equation 1:

$$N = (T - t_0)/t_1 \tag{1}$$

T, the time available for this research, is 14 days; morning time: 10 a.m. – 1 p.m. GMT+8 (3 hours), (3 hours × 60 minutes × 14 days) = 2520 minutes. t_0 is fixed time, 3 hours daily timeframe (3 hours × 60 minutes = 180 minutes). Also, t_1 is the time to complete the questionnaire (20 minutes). The number of samples taken from residents was calculated as follows:

$$N = (2520 - 180)/20 = 117 \text{ samples} \tag{2}$$

2.2. Data Analysis

The respondents were divided into two groups: disposal practices and the reasons for these practices. In this study, there were three types of houses, including stilt houses, half stilt houses, and landed houses. A house on stilts is a house with *kolong* and does not require construction or fencing with massive materials under it. A half-treaded house is a house that was initially in the form of a stage, and then over time, with the development of residential space needs, at the bottom or under it, fences were made of bricks, zinc, or boards. Landed houses are houses without *kolong*. The disposal location, the method of disposal of greywater, and the reasons for these actions were examined. The questionnaire results were analyzed using descriptive statistics and then presented in graphical forms. While qualitative data in the form of data on the physical condition of settlements presented in the form of maps and photographs, and the results of interviews conducted purposively with village staff and community leaders regarding greywater were all analyzed descriptively (Figure 1).

Stilt House Type Half-Stilt House Type Landed House Type

Figure 1. The shape of the house in the object of research

2.3. Description of The Area and Its Context

Karama Village is adjacent to Makassar Strait. It is a dense and irregular settlement. Karama village can be found in rural areas of Takalar Regency, South Sulawesi. It is classified as a slum due to inadequate supporting infrastructure, particularly greywater infrastructure, dense, irregular housing patterns, and its location along the coast.

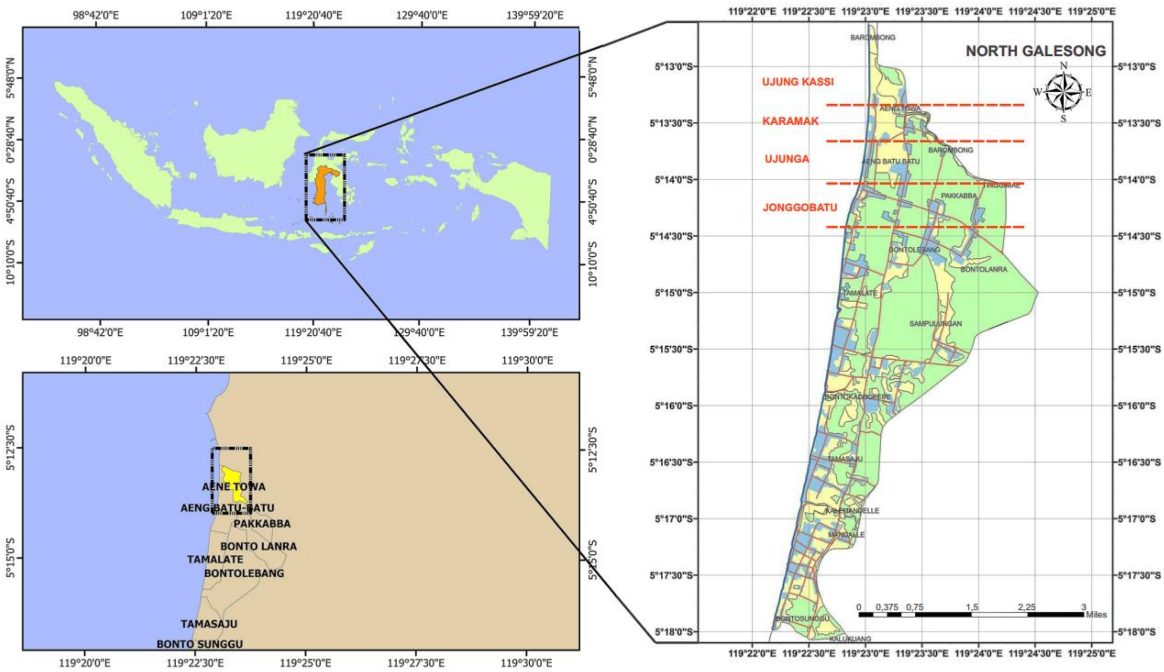

Figure 2. Indonesia-North Galesong District

Karama is one of the hamlets inhabited by people who generally work as fishermen or other related jobs, such as fish cultivators, fish drying, fish sellers, boat builders, and other informal sector workers. Its location is directly adjacent to the sea, causing settlements to be very vulnerable to the effects of tides and floods. Karama Sub District. The left image shows a green open area (green color), a residential area (yellow color), fish ponds and garden areas (brown color), while the left image shows a dense and irregular housing pattern (Figure 3).

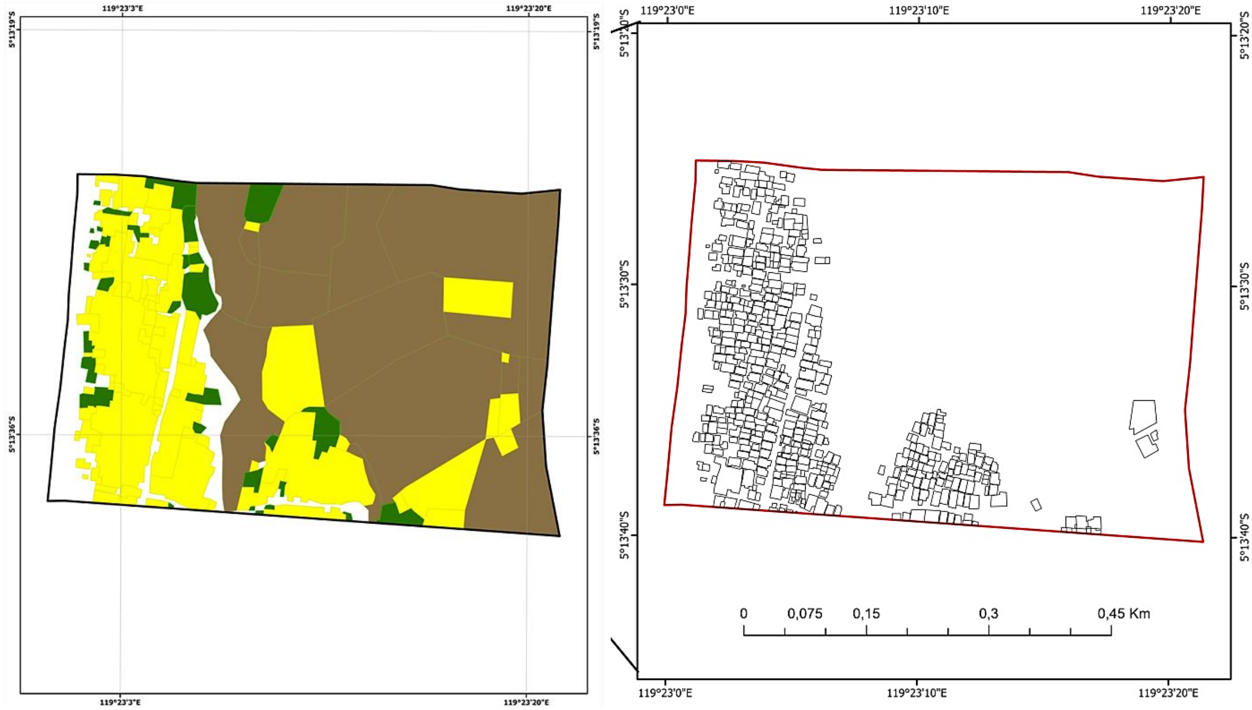

Figure 3. Research location

3. Results and Discussions

According to village office data, there are 298 houses in Karama village, with 90% of them being landed houses and the rest being stilt houses or half-stilt houses (stilt houses fenced with bricks under them). Approximately 70% of the community (heads of households) have completed elementary and junior high school and are employed as fishermen (source: Aeng Batu village Staff, 2022).

3.1. Grey Water Disposal Types and Methods

Figure 4 to 6 demonstrate the various types and forms of environmental-scale greywater disposal (beach and village roads). Dirty water from housing units flows to the beach, creating sewage puddles and an unappealing sight and odor. Environmental drainage is located on village streets and footpaths without a network system. Greywater naturally flows and spills onto the road, creating floods. This situation gets worse during the rainy seasons. Figure 6 depicts washing and bathing activity in the well area, which generates greywater.

Figure 4. Drainage in coastal area

Figure 5. Street drainage condition in residential environment

Figure 6. Activities in the community that produce greywater

Greywater discharge ends up on the beach without any treatment. The wastewater reminiscing on the beach sand turns into a filth and causes bad smells and sights. Main streets and collector streets do not have a greywater drainage network system. Water overflows onto the street even in the dry season; in the rainy season, the water will flooded in the area up to the ankles.

Bathing and washing occur in the well area. The produced dirty water accumulates around the well. There is no drainage channel from the well to the environmental sewer. Thus, greywater seeps back into the well area. Figure 7 depicts the state of the greywater network system in semi-landed houses and landed house units (on a micro scale) in the Karama fisherman settlement.

Figure 7. Semi-landed and landed house in house unit greywater network system (micro scale)

The disposal of greywater from the housing unit's service area to the yard is done openly or through a pipe leading to the drainage hole; if the hole is full, then the occupants of the house dredge and dispose of the greywater into the yard. Some people let greywater run into their neighbour's yard instead of draining it, hoping it will soak into the soil/sand. During the rainy season, the greywater in the temporary reservoir overflows and is washed away by rainwater until the area is clean again.

Greywater from domestic waste includes water from laundry, food waste, urine, and, in some cases, child feces that are discarded without treatment. Figure 8 depicts the greywater disposal system on stilt houses that fall freely to the ground without prior management. The picture also depicts the condition and material of the service area using boards or bamboo arranged with more gaps so that dirt can fall under the house.

Figure 8. Drainage of the house on stilts directly throw to the *kolon*g and the form of grey water disposal from the service area on stilt houses

Greywater disposal on stilt houses flows freely to the house's bottom (*kolong*), forming a sewer area. The area is covered with gravel or bricks to keep dirty water from splashing, and residents sometimes raise ducks or chickens to eat the leftover food scraps. If the volume of wastewater exceeds the capacity of the sewer area, the dirty water will immediately spill into the surroundings. In the service area, residents make holes in the floor so that dirty water easily spills out and does not damage the floor material. Figure 9 depicts the percentage of people who dispose of greywater, and Figure 8 indicates why people dispose of greywater using conventional methods.

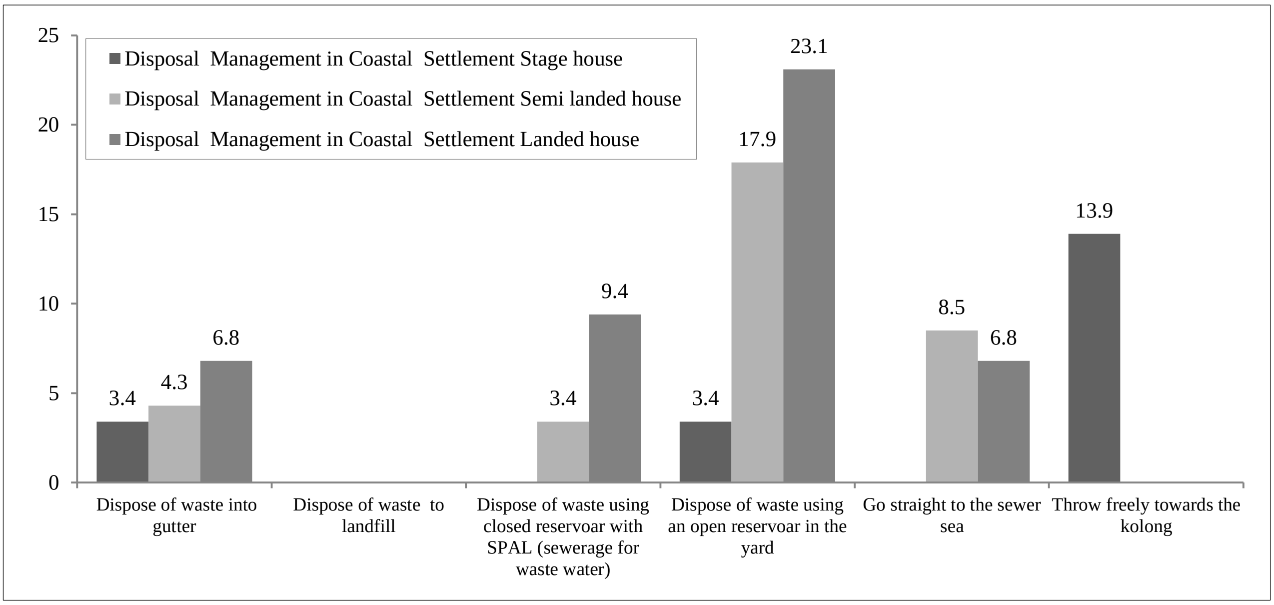

Figure 9. Percentage of people who dispose of grey water

In general, people openly throw greywater into their yards without any prior treatment (23.1% for landed houses, 17.9% for semi-landed, and 3.4% for stage houses), whereas for stilt houses, almost all immediately throw it down to the *kolong* (13.9%). Some people who have lived in landed houses for more than five years dispose of greywater in closed holes designed to look like wells and perform the same function as a septic tank, accounting for 6.0% of semi-landed houses and 3.4% of landed houses. Those who live near the village road will have their greywater directed there (for landed houses 6.8%, semi-landed houses 4.3%, and stage houses 3.4%). Greywater disposal will be directed directly to rivers or seas with open channels for people who live near rivers and beaches, without prior treatment (8.5% for semi-stilt houses, and 6.8% for landed houses).

People throw their grey water directly into the ground for various reasons. Their reasons are that it is easy to seep into the soil/sand (81.2%), easy throw (79.2%), there is no land or special place to dispose of waste (54.5%), there is no proper drainage channel or government preparation (29.7%), it is less costly (28.4%) and easier to clean again after the rain (19.8%). Irregular settlement patterns, the width of the village collector road and the material of the roads is still soil/sand making it difficult to make the channel.

3.2. The Impact of Nature on Greywater Sanitation in Coastal Areas

Figure 4 to 6 depict the condition of greywater in the coastal environment, which overflows everywhere. While the greywater from residential units is clogged, the flow is not smooth, and it is even inundated in sewer mud puddles. According to Figure 10, 81.2% of people said it was easy for it to soak into the sand, and 79.2% said it was simple to do. This perspective lies in the preference for the environmental conditions of their living place and the habit (tradition) passed down from generation to generation of disposing of greywater conventionally. Tradition is defined as something that has been done for a long time and is a part of the life of a community. The environment can dramatically influence people's actions because it can elicit emotions in the interpreter and change decision-making [32, 33]. Humans have long interacted with the environment, so their actions affect the environment or are affected by it. We frequently interact with our surroundings, and influence one another. Humans are compelled to engage in certain behaviors by their surroundings. However, we can also impact on environmental settings [34]. However, as shown in Figure 4 to 8, the puddles formed anthropogenically through greywater disposal indicate that the soil or sand is saturated, and the drainage system is damaged, disconnected, and covered with garbage, causing the drainage system to fail to drain wastewater sufficiently. The community does not realize this, so they continue to behave and have such views on greywater management.

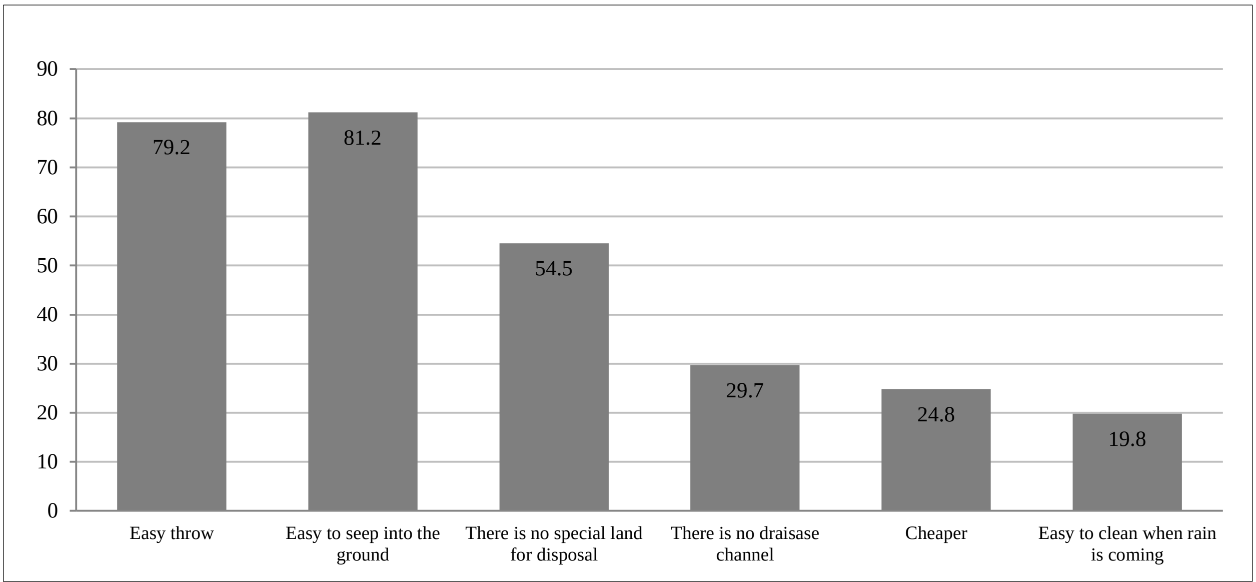

Figure 10. The reason for throwing greywater directly into the ground and open space

One of the environmental impacts of continuous greywater disposal is a reduction in soil absorption and water retention capacity [35]. The land in the settlement is divided into three types: sandy around the beach, a mixture of sand and soil about 30 m from the highest tide limit, and the rest soil. Sandy soil absorbs less water because it comprises 70% large soil particles (0.02-2 mm). Increasing greywater volume on soil will degrade soil structure over time and can increase the potential for groundwater contamination, particularly in shallow water areas and soils prone to leaching [36, 37].

In addition to greywater disposal, coastal areas are low-lying, making them vulnerable to flooding. Rising tides can reduce the height difference and slow the gravity of the drainage even more. Furthermore, storm waves are common during rainstorms and can completely halt natural drainage in coastal areas. Saturated soils increase runoff by reducing water's ability to seep into the sand. Coastal flooding can also be exacerbated by issues frequently overlooked when designing drainage systems. Storm surges can cause seawalls and sediments to flood, and debris can clog inlets, outlets, pipes, and drainage channels. Coastal areas may be entirely submerged by the sea during the worst storm wave, rendering drainage systems ineffective until water levels drop [38]. Rising sea levels and flooding on land are also expected to result in soil puddling and the obstruction of natural drainage structures [39]. This explains that the beach's natural conditions and physical setting significantly correlate with reducing the quality of the absorption of sand.

Locals work on streaming greywater so that it ends up on the beach and can immediately seep into the sand because sand is perceived as a medium that easily absorbs grey water. This method is useful because sand filtration system is a highly active biological unit. The filtration technology employs low-cost sand and is an affordable alternative to quick wastewater treatment. It employs sand as an excellent medium for filtering wastewater [40], but simply letting it absorb into the sand will cause other problems. Most domestic wastewater in Indonesia is generated by greywater that flows through untreated drainage systems. Problems that arise when greywater is not correctly managed and flows directly to the beach or sea can result in seawater pollution and a reduction in quality. Environmental conditions, such as human health in the environment, can impact the condition of marine habitats [41]. With high bacterial loads, nutrient release, biological oxygen demand, and salinity effects, untreated greywater can impact water quality and public health. If left untreated, it can be septic in less than 24 hours [14, 42]. Thus it is vital to treat greywater early so as not to pollute the surrounding environment.

3.3. Community Attitudes and Behavior Toward Grey Water Management

People's behavior contributes to environmental changes or degradation [43] (Figures 9 and 10). Household, agricultural, and industrial activities generate waste, which, if not appropriately managed, will degrade environmental quality [44], and even the behavior of disposing of liquid waste becomes worse because they consider household liquid management too costly [45]. In rural communities, there are behavioral aspects and perceptions that their wastewater will easily seep into the ground. According to Sharma [46], human behavior involves a wide range of human practices influenced by culture, attitudes, emotions, values, ethics, authority, relationships, hypnosis, persuasion, coercion, and genetics. Elele & Subanda [47] hold that behavior is related to dispositional causes (internal traits, abilities, feelings, and personality) or situational causes (such as the situation or environment in which they live).

Figure 10 shows why people disposed of their greywater into open spaces in coastal settlements: dense and irregular settlement situations and poor structural quality of informal housing arrangements and configurations. As a result, most informal settlements are vulnerable to natural disasters [19], due to coastal land in the sand form which they consider easy to absorb dirty water, the low economic capacity of the community in building drainage channels, lack of attention from local governments in providing drainage infrastructure, and lack of public awareness about health environment. Public awareness is critical to waste management success [48]. Figure 10 shows that 81.2% of residents believe that greywater dumped directly into the ground/sand is easily absorbed as the sand particles are porous and usually filled with air when dry. Also, as soon as these particles contact water, the air-filled cavities are filled with water. Since sand absorbs water, particularly during the day when the temperature is high, the infiltration rate increases, with a higher rate occurring during the hot period (during the day) that affects the infiltration rate by 56% (temperature affects the infiltration rate) [49]. After Laos and Myanmar, Indonesia has the third worst sanitation system in Southeast Asia [50].

According to the data status reported by the Indonesian environmental agency in 2002, no less than 400,000 m^3/day of household waste is disposed of directly into rivers and land without prior management. In some rural areas of Indonesia, many people remain impoverished, with minimal sanitation, and many defecate in rivers because they lack a dedicated channel to dispose of their household wastewater. This is even though economic factors, difficult-to-change habits, and relatively low educational quality influence people's lifestyles. According to WHO/UNICEF estimates, approximately 60% of the population in rural Indonesia does not have access to proper sanitation facilities [51]. According to Minh & Huang [52], the behavior of not disposing of waste in the trashcan is due to policymakers and the general public's lack of understanding of the importance of good sanitation. Most Indonesian households are currently unaware of how to manage household waste (wastewater from the bathroom, laundry, and kitchen) and lack access to a sewerage system (SPAL). The following data (Table 1) specifies the Takalar-Indonesia residents' behavior when disposing of household waste [53].

Table 1. Management of greywater

Throw waste into gutter	46,7%
Dispose of waste to landfill	17,2%
Dispose of waste using a closed reservoir in the yard equipped with SPAL (sewerage for wastewater)	13,2%
Dispose of waste using an open reservoir in the yard	17,4%

Comparing Table 1 with Figure 9, people living in the study area who discharge greywater into sewers are smaller in number than those in urban areas because they do not have a sewer system. If there is one, it is incremental, not continuous, located only on the edge of the main village road, and made by individuals who located the residence adjacent to the main road. Another noticeable difference is the disposal of waste using an open reservoir in the yard, which is 44% in coastal settlements. This happens because there is no drainage system from the residential service unit to the drainage channel, making people dig holes around the service area to collect the wastewater. Some who live around the coast throw directly to the beach (15%), and some throw freely towards the underside (13.9%). In the last two RISKESDES (Indonesian Basic Health Research) reports, it is not mentioned, while in this study it is one of the variables, this happens (throw freely towards *kolong*) because the settlements that are the case have their own character, namely in coastal areas with several housing types, one of them is stilt house.

People dispose of their greywater freely in dense and slum coastal areas without holding and managing it, with the highest percentage of other greywater disposal methods (58.92% in Table 1 and 44.4% in Figure 9). It occurs due to the settlement's lack of a drainage system on the side of the road in the residential area. If there is one, it is short and not continuous. According to the data in Figure 8, 100% of the stilt houses will dispose of their dirty water openly and without treatment directly under the house, and if it overflows, the water will flow into the yard. According to Devi [54], education influences a person's attitude toward waste disposal. The level of public education and waste management behavior in fishermen's settlements have a significant relationship. It can also be seen in Karama village, where 70% of the people, particularly the household heads, have a low education level, yet socialization and interventions related to greywater are still insufficient, primarily at the elementary and junior high school levels. Charles Darwin was correct, and we have come to understand and accept the Dunning-Kruger effect in recent years: the cognitive bias that states that the less we know, the more confident we are. The state gave new meaning to the adage, "Little knowledge is dangerous." Dunning and Kruger demonstrated that people with little knowledge about a particular subject are confident and outspoken about it [55].

Critical barriers to improving WASH (water, sanitation, and hygiene) practices identified included low investment in WASH infrastructure, inadequate knowledge about water-borne diseases, and lack of community involvement [56]. To remove these barriers, government intervention is needed to improve sanitation conditions. These efforts should be holistic and emphasize improving the microenvironment, providing better access to sanitation infrastructure, and promoting more hygienic behavior practices in the community [57].

3.4. The Impact of Grey Water on The Environment and Public Health

The community generates a significant amount of grey water. Taking the number of residents with each person needing 60 liters of clean water/day (Standard for Clean Water Needs) [58], from which 80 percent will turn into wastewater, and 75 percent of the total wastewater is grey water. According to data from Aeng Batu's village office, the number of houses in Karama village is 298. If each household has an average of five family members, the need for clean water is 60×1490 people = 89400 liters/day; the remaining 80% will be wastewater = 71520 liters/day. Thus, 53640 liters/day of greywater will pollute the soil/sand in residential areas. The long-term effects of greywater disposal on the soil will reduce soil structure over time and may worsen the potential for greywater contamination of groundwater, particularly in areas with shallow groundwater and bleaching-prone sands [37]. In general, greywater contains high concentrations of biodegradable organic matter and several standards of constituents produced by the household, such as nutrients like nitrate and all its derivatives, phosphorus and its derivatives, including xenobiotic organic compounds (XOCs), and biological microbes like fecal coliforms, salmonella, and common hydrochemical constituents [25].

Greywater contributes 50-80% of the water volume to domestic wastewater, and it contains 18–22% potassium (K), 20–32% phosphorus (P), and 9-14% nitrogen (N), respectively, so that it can be reused after simple maintenance [59]. Domestic wastewater, chemical waste, laundry, and human/animal seepage are all likely to impact well water quality. Detergents and chemicals used in kitchens, dishwashers, and washing machines can contribute to nutrient levels in wells [60]. Because the floors and drains are not waterproof, waste from human waste disposal sites, latrines, and animals can seep into the wells, and the construction does not account for the distance between the well and the pollutant source [61]. The quality of infiltration well water that arrives from groundwater carries residue from the soil, according to Fuller [62], and it is important to note that the presence of pollutant sources can seep into the well. Asmal et al. [40] found that several pollutants originating from greywater have polluted wells in coastal areas, such as Kmn04, E Coly, and coliform, in amounts that exceed the limits required in SNI (Indonesian National Standard). Cause the wells have been closed and no longer function properly. Based on the data and the outcomes of the discussion, the following are the main factors that influence community attitudes toward greywater management in coastal areas.

Our findings suggest that attitudes are influenced by the physical and natural environments, demographics, and the role of the government. This is true in nearly all traditional coastal settlements, both urban and rural. Attitudes that have taken root and become a culture in greywater management that do not meet environmental health requirements are undoubtedly worthy of public and government scrutiny. Changing the existing mind-sets about handling greywater is challenging as lived experience and ignorance hamper the change process (Figure 11).

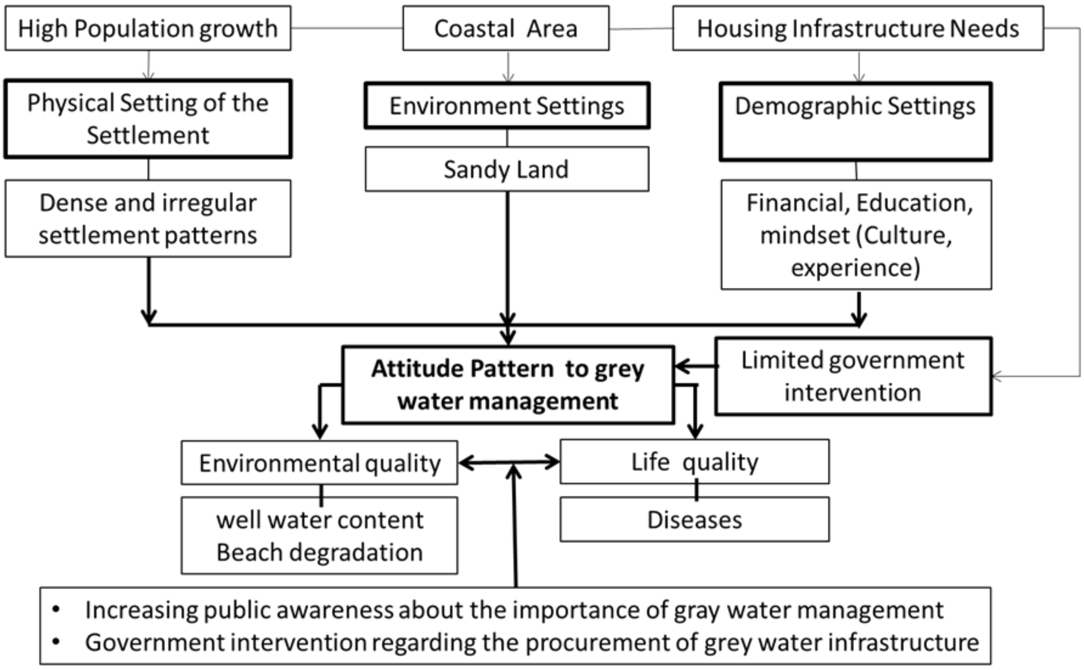

Figure 11. Scheme of Influence and impact on attitude pattern to grey water management

3.5. Grey Water Management Strategy for Coastal Slums

Greywater refers to the part of domestic sewage that does not contain human waste. The primary sources of greywater are laundry, bathing, and kitchen drainage. This type of wastewater has tremendous potential to be reused [30]. The treatment of greywater converts it into a source of clean water for secondary purposes, such as washing and watering latrines, plants, and other plants. Greywater reuse systems are designed to achieve favourable environmental and socioeconomic consequences for rural communities [26].

However, due to limited space and dense occupancy in coastal settlements, preparing vacant land for this will be difficult, so the solution is to create environmental drainage channels, such as greywater processing containers. The drainage channels on the left and right sides of the road will continue to drain cloudy water, but there is something unique about using the channel as a greywater treatment (as illustrated in Figure 12). The canal is divided into segments, each 200 meters apart, and public toilets are built at the end of each segment. Each segment is broken down into four sections: Section 1 is responsible for the initial filtration of large waste (leaves, stones, wood), after which dirty water is collected and precipitated. Section 2 filters the toxic substances in greywater using sand, gravel, palm fibers, and aquatic plants that can survive in wastewater, such as *APU* wood (*APU* wood can be used to absorb metal compounds in wastewater), water hyacinth (It has been found that water hyacinth can be a cleaner and remove heavy metal contaminants mixed with other metals in water, and water star (*Cyperus alternifolius*) to absorb nitrogen and phosphorus. Section 3 controls greywater quality with lotus and ornamental fish. Given the high temperatures in coastal areas, the lotus provides shade for the fish and regulates the pond temperature to keep it cool. The use of fish as a biological method to detect water clarity is based on existing research [63]. Zaghloul et al. [64] report five major groups of biological indicators of aquatic ecosystems: algae, bacteria, protozoa, macroinvertebrates, and fish. The difference between the greywater treatment strategy and previous research is that this treatment plan utilizes the drainage channel itself as a treatment site and uses filtering from natural materials available in the village, thereby saving space and costs. Figure 13 depicts an idealized flow of how greywater is treated.

Figure 12. The illustration of the ideal design of a drainage channel

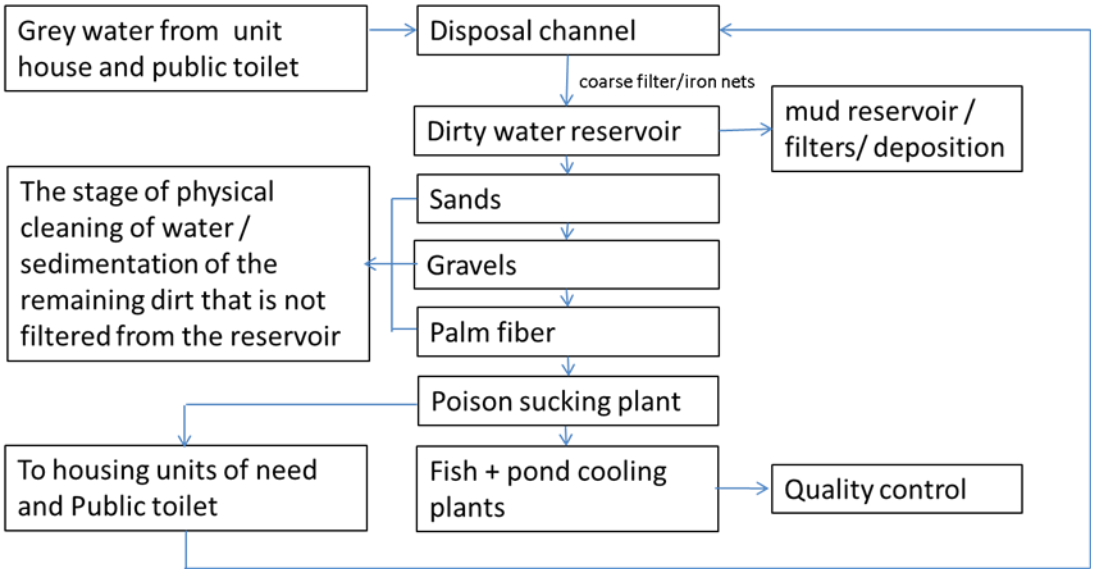

Figure 13. Scheme of grey water treatment horizontal flow

4. Conclusions

The disposal of greywater has an impact on the environment. Judging from the natural setting aspect, people dump greywater directly into the ground, open space, or beach to make it easy to absorb, but people are less aware that sand/soil conditions can be saturated due to tides and storm waves. Saturated soils can also be caused by the continuous infiltration of greywater containing fatty substances and nutrients that will increase runoff by reducing the ability of water sands to absorb water. A review of the aspects of the physical arrangement of the housing environment, such as the density and irregularity of the arrangement of houses, the unavailability of land for providing greywater infrastructure, and the narrow and irregular circulation network, complicates the creation of a greywater disposal network system. In addition, the government is still less involved in handling greywater, both in terms of providing physical facilities and infrastructure as well as socializing and counseling the general public about the importance of good sanitation.

The attitudes and perceptions about greywater are strongly influenced by dispositional or situational factors leading to potential indifference to the existing conditions. The impact of this condition ultimately affects the quality of the environment and the community's quality of life. The decline in environmental quality can be seen from the number of wells that are closed and no longer used because they have been polluted and contain materials that exceed the limits required by SNI (Indonesian National Standard), especially Kmn04, E Coly, and coliforms, which are harmful to health if consumed frequently. Meanwhile, from the aspect of quality of life, it will affect the health status of the community. The theoretical research benefit for science related to greywater is the finding that there are four push factors that influence people's attitudes or actions towards greywater i.e., settlement physical arrangement and natural setting, demographics, and government, that cannot be separated.

It is necessary to pay attention to the production of large quantities of greywater so that it can be used as an alternative source of clean water for secondary needs, such as watering plants, flushing closets, washing, and others, considering that in coastal areas, especially during the dry season, the availability of clean water from wells and water supply from local water companies decreases. This strategy by adjusting to the natural conditions of the coast, the physical conditions of settlements, and community conditions. It is necessary to utilize existing resources and harmonize with nature so that the management of the horizontal greywater drainage system is a suitable alternative because it is easy to use, economical, and safe. The results of this research can be implemented to help attain clean water in coastal areas. The treated greywater can be a source of clean water for the secondary needs of the community. For this reason, it is highly expected that there will be financial assistance from the government or stakeholders for its implementation.

5. Declarations

5.1. Author Contributions

Conceptualization, I.A.; methodology, I.A., and E.S.; writing—original draft preparation, I.A., E.S., S.A., and M.A.W.; writing—review and editing, I.A., E.S., S.A., and M.A.W.; supervision and project administration, I.A.; funding acquisition, I.A. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available in the article.

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5.4. Conflicts of Interest

The authors declare no conflict of interest.

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