Strategy of Household Wastewater Management with Reduce, Reclaim and Reuse System (3R)

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Abstract- Clean water used in daily activities in the household will mostly be wasted as waste, both gray water and black water. Waste water classified as black water is generally processed simply using septic tanks while used water is discharged directly into the drainage channel and then into the environmental media. Waste water should be managed before being discharged into environmental media. Waste water management can be carried out through reduction, processing and utilization or disposal. The method used in this study is to review the results of previous research by adding primary data to develop a strategy for managing household wastewater. Interviews were conducted with stakeholders of household wastewater management to formulate wastewater management policies that will be carried out and allow them to be implemented in the future. Based on the simulation results obtained the value of sensitivity O/M ratio obtained an average value of 1.91. Simulation of optimistic conservative conditions should be a concern in determining wastewater management policies, especially at the stage of wastewater treatment which has a value that is 2 times greater than moderate conservative conditions. Waste water treatment is more effective in reducing the BOD pollution load that will enter the environmental media compared to the reduction and reuse of waste water. Wastewater treatment can reduce pollution loads by up to 41.1% but with integrated wastewater treatment with reduction of wastewater and reuse of waste water can reduce BOD pollution load to reach 71.28%. The strategy is to arouse and build public awareness through counseling to reduce waste water and reuse waste water that has been treated.

Keywords- Strategy, household wastewater management, reduce, reclaim, reuse

I. Introduction

Water is a resource that is vital for the survival of humans and other living things. Therefore, water resources must be protected so that they can still be utilized properly by humans and other living creatures. The use of water for various purposes must be carried out wisely, while still calculating the interests of the current generation without reducing the interests of future generations to obtain the same water resources that we have now. Lately, water has become a problem that needs serious attention and savings. To get good water according to its designation standards, it is now an expensive item because a lot of water is polluted by waste originating from human activities, such as household activities, industry, agriculture, livestock, and other activities [1].

Household, industrial, and all activities that produce waste water should carry out waste water management. If all human activities pay attention to the management of waste water produced, the problem of shortages and water pollution does not really need to worry. But in reality there are many industries and other activities that dispose of their waste into environmental media through drainage, canals, rivers, sea and other water bodies without management. Disposal of waste water directly into environmental media which is the cause of water pollution. Waste, both in liquid and solid form even the gas that enters the environmental media causes a deviation from the normal state of water. Water irregularities from normal conditions indicate water pollution has occurred.

Waste water management carried out, especially by business actors and / or activities is still limited to wastewater treatment; not yet integrated waste water management. Waste water management should be carried out through stages of reducing, processing and reusing waste water.

Reduction of Household Wastewater

Reduction of household wastewater, especially used water, is carried out at the source, namely from households. Reduction of used water in the household can be done by reusing used water according to its designation. Domestic wastewater can also be processed simply and the results can be used for watering plants, pet consumption, fertilizer sources for plants or for fish ponds [2], [3], [4], [5].

Management of wastewater or used water at the household level is carried out by: 1) general disposal through waste water storage located on the yard, 2) used for watering plants in the garden, 3) discharged into the infiltration field, 4) flowing to open channels, and 5) are channeled into closed channels or gutters with a filtration system [6], [7]. While excreta management is carried out with a dry system or night soil such as digging pit latrines and wet systems such as septic tanks [8], [9], [10].

Based on the [11], it is explained that by increasingly relying on the industrial sector to sustain economic growth, the added value of manufacturing is expected to increase 13-fold and the resulting waste increases 10-fold if the process continues as it is today. If it cannot be stopped or reduced, the cost of processing and disposal of waste water so that the quality standard of waste

and environmental quality standards can be met will be very high. If no processing is carried out, the level of pollution will increase considerably from the current high pollution level. Therefore, it would be more effective to try to "minimize waste water" and save costs for wastewater treatment. In addition, minimizing wastewater not only reduces waste water that must be collected, processed and disposed of but also reduces the use of raw materials, energy and water [12]. Furthermore, the pollution load that enters the environmental media will also decrease. Pollution load in urban areas in Java with and without waste minimization illustrates how a minimization factor of 50% can reduce pollution loads from 370,000 tons to 185,000 tons in 2020 [11].

The wastewater management strategy should be a strategy that starts where waste is produced until the waste water is discharged. This kind of strategy can be divided into steps and actions in synergy, namely: 1) minimizing wastewater, efforts to reduce wastewater both from industry and those produced from households, 2) improving services, this program is more directed at improving household wastewater services , because industrial wastewater is usually managed by each industry, and 3) processing and disposal, the waste produced still needs to be processed and disposed of in an environmentally friendly manner [13], [14], [15], [16].

Waste water management has been concentrated in improving service, processing and disposal, while minimizing wastewater is still lacking in attention [17], [18]. To achieve success, the three steps above must be implemented in an integrated and inseparable manner [19], [20], [21].

Reduction of waste water can be done by making efficient use of water. Efficiency of water use can be applied by using water-saving technology, for example replacement of bathtub to shower, changing shower pressure by using lower pressure, applying reuse of towels and bed sheets and using recycled waste water for watering plants [22], [23]. The implementation of an efficient water use program has been implemented in hotels in Yogyakarta, Indonesia, indicating that the efficiency of water use can save clean water use by 7.2 - 8.9% per year. With a comprehensive study of all activities that use a lot of clean water, water efficiency efforts that are carried out consistently can reduce the level of water consumption by 23-30% [24].

Reclaim or Recycle of Household Waste Water

Waste water sourced from households consists of gray water [25], [26] and waste water mixed with excreta in the form of feces and urine (black water). Waste water classified as gray water is generally discharged directly into sewers or rainwater channels 27], [28], while wastewater classified as black water is channeled to individual or group septic tanks [29].

Based on observations in the field that the disposal and treatment of human waste with existing systems mainly relies on local systems, in areas with low ground water levels with low to moderate population densities, and suitable soil conditions are considered still sufficient. But in areas with high population density, where the distance between houses and septic tanks is getting closer, the processing of the local system is already not possible because it can pollute ground water. According to [30], that 40% of well water samples are known to contain E. coli with the number of colonies identified, namely> 2400/100 ml. This shows that the well water has been contaminated with E. coli bacteria and does not meet the requirements of clean water.

Well designed and operated septic tanks can significantly reduce BOD [30]. Most septic tank sanitation systems are not managed properly, so their ability to treat wastewater is also limited. Septic tanks are not routinely emptied and mud collection services from septic tanks often dispose of mud in canals or rivers [11]. In contrast to the processing of WWTPs which significantly reduced BOD to 58%, although BOD concentrations still exceed the required quality standards [31], [32].

Waste water treatment aims to reduce BOD, COD, nutrients, particles mixed and kill pathogenic organisms [33], [34] , [35] , [36]. In addition, additional processing is needed to eliminate nutrients, toxic components, and materials that cannot be degraded so that the concentration becomes low [37].

The wastewater treatment system consists of an on-site system and an off-site system. The selection of individual, communal and semi-communal systems is determined based on local conditions, rainfall, occupancy density, population and socio-economic conditions [38]. Communal and semi-communal systems can be applied to people who do not have private latrines, low economic levels, slums, and densely populated areas [39], [40].

The process of treating wastewater containing organic compound pollutants, the technology used in large part uses the activity of microorganisms to decompose organic compounds contained in natural wastewater. The process can take place in aerobic or anaerobic or in facultative conditions. The aerobic process is usually used for wastewater treatment with a BOD load that is not too large, whereas anaerobic process is used for wastewater treatment with a very large BOD load [41], [42].

The selection of waste water treatment technology must consider several things, including the amount of wastewater to be treated, expected quality of processed water, ease of management, availability of land and energy, and the lowest possible operational and maintenance costs [43]. Waste water treatment with on-site or decentralized systems and ecobiological systems are generally very simple, low-cost and easy to maintain.

Each type of wastewater treatment technology must pay attention to the technical aspects, economic aspects, environmental aspects and human resources that will manage these facilities [44], [45], [46]. The most important aspect to be considered in processing the benefits is the quality of treated water must meet the waste water quality standards. The choice of technology is always directed to get more innovative technologies to meet the waste water quality standards.

Reuse of Household Waste Water

Increasing population and economic growth, the potential for environmental pollution will also increase. Therefore, the management and safety of waste water disposal is very important to maintain public health and reduce the level of environmental degradation. In addition, adequate wastewater management is also needed to prevent contamination of water bodies for the purpose of preserving water resources.

One of the most promising efforts to stem the global water crisis is the processing of industrial wastewater and municipal wastewater for reuse [47]. The WateReuse Association defines the reuse, recycling or reclamation of water as "water used more

than once before the water returns to the natural water cycle" [48], [49]. Thus, water recycling is the reuse of wastewater treated for beneficial purposes such as agriculture and landscape irrigation or household gardens, industrial processes, toilet flushing, or filling groundwater basins or as groundwater recharge, washing cars, and fire fighting [23].

Reuse of wastewater allows communities to become less dependent on groundwater and surface water sources and can reduce the diversion of water from sensitive ecosystems. In addition, reuse of water can reduce the nutrient burden of dumping waste water into waterways, reducing and preventing water pollution, and saving energy consumption [50]. This 'new' water source can also be used to fill water source quotas that have been used excessively [51], [52], [23].

According to [53], that Australia has changed the thinking pattern for 40 years about wastewater from the issue of disposal to recognize wastewater as a legitimate and valuable resource but recycled water that can be drunk directly does not receive community and political support in to date. In contrast to the Singapore government which has taken an active role in communicating accurate scientific facts and taking a persuasive approach to reuse of wastewater. Reuse of wastewater is part of the Singapore government's master plan to cover the water balance deficit by increasing the quality of urban wastewater to the quality of drinking water [54].

Waste water that has been through the processing will eventually be discharged into environmental media or water bodies, which are discharged into canals, rivers, lakes or into the sea. Waste water to be discharged into a water body must meet the required quality standards so as not to have an impact on the surrounding environment [47].

Domestic wastewater, especially those sourced from households should be seen as a resource, especially water resources and nutrient content contained therein [55]. Processed wastewater can be used for agricultural irrigation and the mud can be used as fertilizer [8], [56]. Waste water contains chemical elements needed by plants for their growth, both macro elements and essential elements. Therefore, the reuse of waste water can reduce the costs spent on fertilizers, and the resulting water is considered safe because it has been treated and is pathogenic free [57].

Waste water treatment systems are usually adapted to technical and economic criteria, such as the removal efficiency of specific pollutants, construction costs, but rarely based on their suitability for potential reuse [58]. However, recycling and reuse affect the entire "water cycle", from supply to final disposal. Therefore, these practices will influence how to design, build and operate water infrastructure and sanitation.

This study aims to formulate a strategy for managing household wastewater to reduce pollution load.

II. RESEARCH METHOD

The method used in this research is to review previous research by adding primary data to develop a strategy for managing household wastewater.

Data Collection Methods

The data collected in this study consists of primary and secondary data. Primary data was obtained from interviews with stakeholders of household wastewater management in Makassar City, consisting of Local Development Planning Agency, Public Works Agency, Environmental Management Agency, Healt Office, and Wastewater Management Units. Interviews were conducted with stakeholders of household wastewater management to formulate wastewater management policies that will be carried out and allow them to be implemented in the future. While the secondary data used is the data from the previous author's research on "the dynamic model of household wastewater management to reduce BOD pollution load" through the stages of reducing, processing and reusing household wastewater.

Primary data from interviews with stakeholders of household wastewater management and secondary data from previous studies were then simulated with the help of Powersim Studio 10 Academic software. The simulation results obtained are then used to formulate household wastewater management policies and strategies.

III. RESULTS AND DISCUSSION

Management of household wastewater should be carried out as a series of activities consisting of activities to reduce, process and reuse wastewater. According to [59], that the management of household wastewater through stages of reduction, processing and reuse can reduce the BOD pollution load entering the ambient environment to reach 71.28%. For details, can be seen in Figure 1 and Table 1.

The model scenario is simulated from controlled inputs which is a major factor in supporting a decrease in BOD pollution load originating from households. Factors that influence the behavior of the model which are also the needs of each stakeholder, namely: 1) extension of household wastewater management, 2) household waste treatment technology that effectively reduces BOD pollution load, 3) waste water management through a reduction , processing and utilization of household wastewater, and 4) law enforcement.

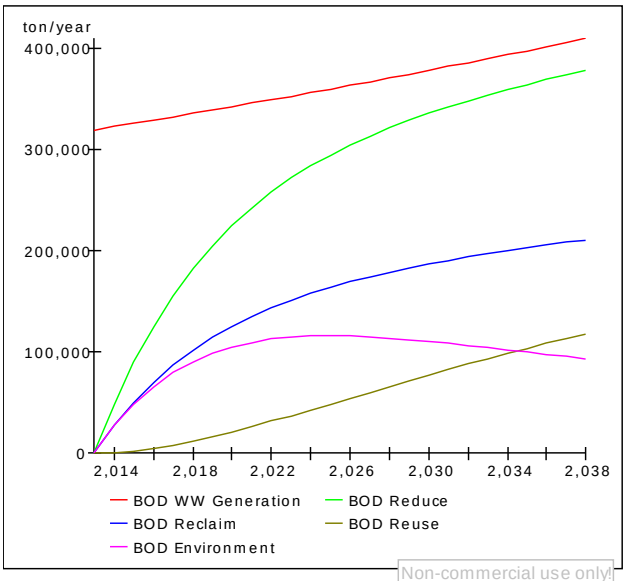

Figure 1. Projected Load of BOD Pollution that Enter Environmental Media After Management (Parabang, et al., 2019)

Table 1. Percentage of decreasing BOD pollution load in each management stage

Management stage	BOD pollution load (ton/year)	Percentage	
		Decrease	Accumulation
Without management	409,966.60	-	-
Reduce	379,122.26	7.52	7.52
Reclaim or recycle	210,622.56	41.10	48.62
Reuse	117.740.66	22.66	71.28
BOD pollution load that enters the environment	92,881.90	28.72	100.00

Source: Parabang, et al., 2019

Based on the data in Table 1, a household wastewater management policy can be formulated by conducting a model simulation scenario. Model simulation scenarios are made from the largest sensitive values seen from existing (conservative) or untreated conditions to moderate, and from moderate to optimistic. For details, can be seen in Table 2.

The condition scenario in Table 2 is the result of discussions with stakeholders. This scenario is the dominant condition that will occur in the future that can be applied by stakeholders.

Table 2. Condition Scenario

No	Policies	Future Conditions	
		Moderate Conservatives	Optimistic Conservatives
1	Extension or awareness of household wastewater management	Increased counseling or awareness to increase home connections to 4.5%	Counseling the benefits of reducing and utilizing wastewater, increasing the home connection to 5% and counseling carried out twice a year
2	WWTPs Technology	WWTPs performance improvement 45%	Increasing home connection to 5.5% and WWTPs performance 50%
3	Management of household wastewater	Decrease in BOD reduction of 17.5%, utilization of 9%	Decrease in BOD reduction of 20%, utilization of 13% and performance of WWTP 50%
4	Law enforcement	The reduction in the 72% BOD pollution load is specified in the City Sanitation Strategy which is approved by the Mayor	Prohibition of disposing of waste water without management and a reduction in 75% BOD pollution load is specified in the City Sanitation Strategy which is approved by the Mayor

Waste Water Reduction (R1)

BOD pollution load of waste water generation with no management conditions or bussiness as usual (BAU) in 2017 amounted to 332,451.84 tons which decreased to 155,315.81 tons in the same year by reducing wastewater or decreasing by 53.28 %. Along with the increase in population, at the end of the simulation in 2038 it increased again to 379,122.26 tons or only decreased by 7.53%. Therefore, policy interventions are needed to continuously reduce the BOD pollution load of wastewater which is disposed directly into the environmental media.

Policy interventions to reduce BOD pollution load are carried out by creating scenarios for moderate conservative and optimistic conservative conditions. The optimistic conservative scenario can reduce the BOD pollution load to 118,584.07 tons and moderate conservative conditions by 136,160.95 tons in 2017. The decrease in BOD pollution load until the end of the simulation in 2038 is 368,992.22 tons in a optimistic conservative condition and under conditions moderates conservative of 372,964.56 tons. Decrease in BOD pollution load with a optimistic conservative scenario of 1.07% of conservative conditions or 9.99% of BAU conditions.

The important thing to note in the scenario of reducing wastewater is the existence of extension activities. Extension activities can increase public awareness to reduce waste water. Reduction of wastewater can be done by utilizing waste water for flushing toilets, watering plants or parks and watering yard or roads. To be clear, the simulation of waste water reduction scenarios can be seen in Table 3 and Figure 2.

Table 3. Scenario of Decreasing BOD Pollution Load through Reduction of Household Wastewater

(ton/year)

year	BAU	Konservatif	Moderat	Optimis
2,013	319,441.73	0.00	0.00	0.00
2,014	322,645.73	47,916.26	39,930.22	31,912.23
2,015	325,881.86	89,125.68	75,668.96	62,560.11
2,016	329,150.46	124,639.11	107,618.41	91,527.82
2,017	332,451.84	155,315.81	136,160.95	118,584.07
2,018	335,786.33	181,886.21	161,655.05	143,629.98
2,019	339,154.27	204,971.23	184,433.02	166,659.68
2,020	342,555.98	225,098.69	204,800.09	187,730.70
2,021	345,991.82	242,717.28	223,034.50	206,942.02
2,022	349,462.12	258,208.46	239,388.31	224,417.78
2,023	352,967.22	271,896.51	254,088.54	240,295.53
2,024	356,507.48	284,057.12	267,338.77	254,717.85
2,025	360,083.25	294,924.67	279,320.78	267,826.43
2,026	363,694.89	304,698.46	290,196.28	279,758.13
2,027	367,342.75	313,547.92	300,108.72	290,642.43
2,028	371,027.20	321,617.15	309,184.93	300,599.93
2,029	374,748.60	329,028.65	317,536.83	309,741.54
2,030	378,507.33	335,886.65	325,262.89	318,168.31
2,031	382,303.76	342,279.75	332,449.63	325,971.56
2,032	386,138.26	348,283.35	339,172.90	333,233.22
2,033	390,011.23	353,961.59	345,499.10	340,026.46
2,034	393,923.04	359,369.03	351,486.24	346,416.24
2,035	397,874.09	364,552.13	357,184.98	352,460.04
2,036	401,864.77	369,550.43	362,639.47	358,208.53
2,037	405,895.47	374,397.58	367,888.18	363,706.25
2,038	409,966.60	379,122.26	372,964.56	368,992.22

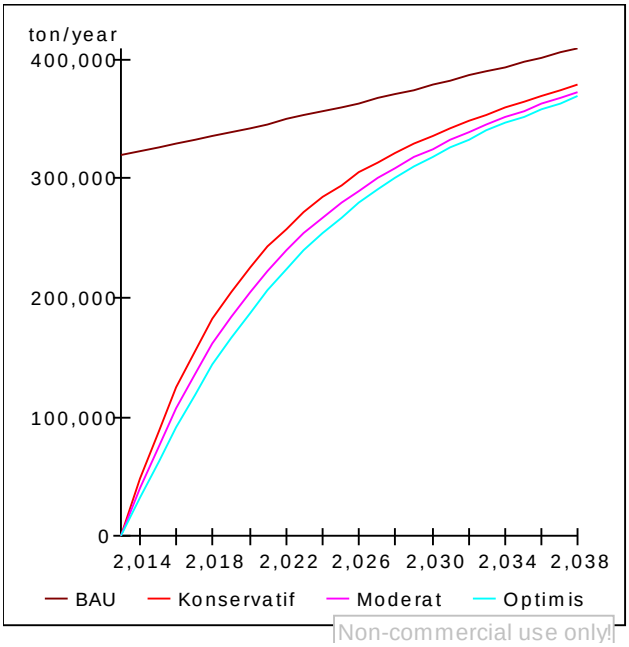

Figure 2. Scenario of Decreasing BOD Pollution Load through Reduction of Household Wastewater

Waste Water Reclamation or Recycling (R2)

BOD pollution load of waste water generation without management at the beginning of the simulation in 2013 was 319,441.73 tons, in 2017 it increased by 332.451.84 tons and continued to increase along with the increase in population, until 2038 or at the end of the simulation reached 409,996.6 tons. The BOD pollution load has decreased with the management through the stages of reducing and treating wastewater. Decreasing BOD pollution load by reducing it then continued with wastewater treatment reaching 48.63% from unmanaged conditions or BAU at the end of the simulation in 2038. Although the BOD pollution load has decreased but in quantity has increased with increasing numbers population. Therefore, there is a need for policy intervention to continuously reduce the BOD pollution load that enters the environmental media.

Policy interventions to reduce BOD pollution load are carried out by creating a scenario of moderate conservative and optimistic conservative. Moderate conservative conditions were able to slow the increase in BOD pollution load to 198,091.38 tons at the end of the simulation in 2038 or be able to reduce pollution load by 5.95% from conservative conditions. BOD pollution load with a optimistic conservative scenario at the beginning of the simulation in 2013 amounted to 25,027.38 tons, 2017 increased to 80,214.4 tons and at the end of the simulation in 2038 reached 180,083.07 tons. The decrease in pollution load is 14.52% of conservative conditions or 9.57% of moderate conservative conditions. To be clear, a simulation of a wastewater treatment scenario can be seen in Table 4 and Figure 3.

Decreasing BOD pollution load through wastewater treatment activities is largely determined by available processing infrastructure, technology or processing systems and capacity or capacity of WWTPs. The greater the capacity of the WWTP, the greater the number of house connections that can be accessed. Likewise, the better the performance of WWTPs, the lower the BOD pollution load will increase. Based on Figure 2 shows that with the construction of the Losari WWTP with a capacity of 14,405 SR, the decrease in BOD pollution load began to decline in 2021 and reached the lowest decrease in BOD pollution load in 2024 for the optimistic conservative scenario. But the expansion in 2025 has increased again as the population increases but the increase is slower than the conservative and moderate conservative scenario.

Table 4. Scenario of Decreasing the Load of BOD Pollution through Household Waste Water Treatment

(ton/year)

year	BAU	KOnservatif	Moderat	Optimis
2,013	319,441.73	0.00	0.00	0.00
2,014	322,645.73	26,620.03	25,752.02	25,027.38
2,015	325,881.86	49,514.05	47,764.23	46,290.54
2,016	329,150.46	69,243.65	66,607.64	64,735.68
2,017	332,451.84	86,286.18	82,852.91	80,214.40
2,018	335,786.33	101,047.45	96,679.07	93,504.06
2,019	339,154.27	113,872.41	108,444.13	104,286.29
2,020	342,555.98	125,054.28	118,663.02	112,921.32
2,021	345,991.82	134,842.34	127,950.84	121,759.73
2,022	349,462.12	143,448.52	136,117.17	128,303.14
2,023	352,967.22	151,052.96	143,073.30	133,671.12
2,024	356,507.48	157,808.82	149,201.00	138,300.31
2,025	360,083.25	163,846.32	154,909.18	142,891.00
2,026	363,694.89	169,276.18	160,042.87	146,902.74
2,027	367,342.75	174,192.53	164,691.05	149,679.94
2,028	371,027.20	178,675.41	168,929.41	152,768.14
2,029	374,748.60	182,792.90	172,822.30	156,288.61
2,030	378,507.33	186,602.88	176,424.46	159,546.16
2,031	382,303.76	190,154.58	179,782.44	162,582.88
2,032	386,138.26	193,489.90	182,935.83	165,434.59
2,033	390,011.23	196,644.47	185,918.32	168,131.75
2,034	393,923.04	199,648.59	188,758.58	170,700.29
2,035	397,874.09	202,528.08	191,481.01	173,162.26
2,036	401,864.77	205,304.89	194,106.36	175,536.45
2,037	405,895.47	207,997.74	196,652.33	177,838.85
2,038	409,966.60	210,622.56	199,133.97	180,083.07

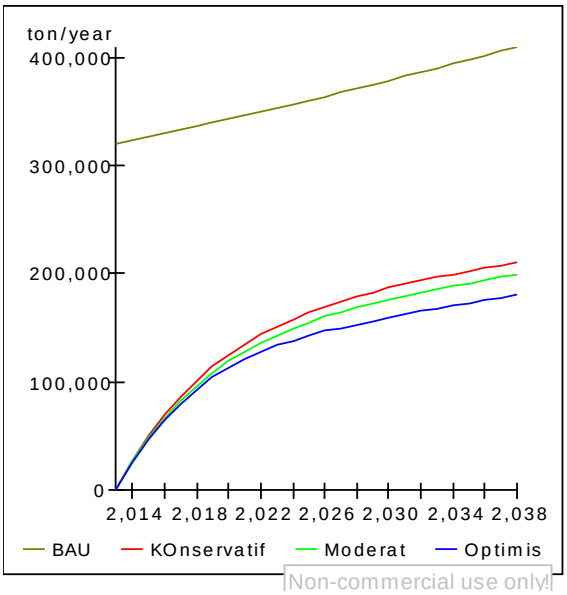

Figure 3. Scenario of Decreasing BOD Pollution Load through Waste Water Treatment

If the WWTP infrastructure is available, the important thing that needs attention is community participation in accessing WWTP infrastructure. One way to increase community participation in connecting houses or connecting to wastewater pipelines is to increase public awareness through counseling.

Waste Water Reuse (R3)

The decrease in BOD pollution load has decreased after gradual management through reduction and treatment of wastewater. The reduction in BOD pollution load can still be reduced by utilizing treated wastewater. The BOD pollution load from the BAU condition decreased by 71.28% after utilization. A decrease in BOD pollution load can be reduced through policy intervention. Policy intervention is carried out by making a moderate conservative and optimistic conservative scenario.

Moderate conservative conditions can reduce BOD pollution load by 1,064.8 tons in 2015, 2017 increased to 5,124.47 tons and at the end of the simulation reached 79,248.87 tons or a decrease of 32.69% from conservative conditions. The conservative optimistic condition is able to slow the increase in BOD pollution load until 2025, namely after the functioning of the Losari WWTP. But in 2026 there was an increase along with population growth, so that at the end of the simulation in 2038 it reached 62,259.55 tons or a decrease of 21.44% from moderate conservative conditions and 47.12% from conservative conditions. To be clear, a scenario simulation of waste water utilization can be seen in Table 5 and Figure 4.

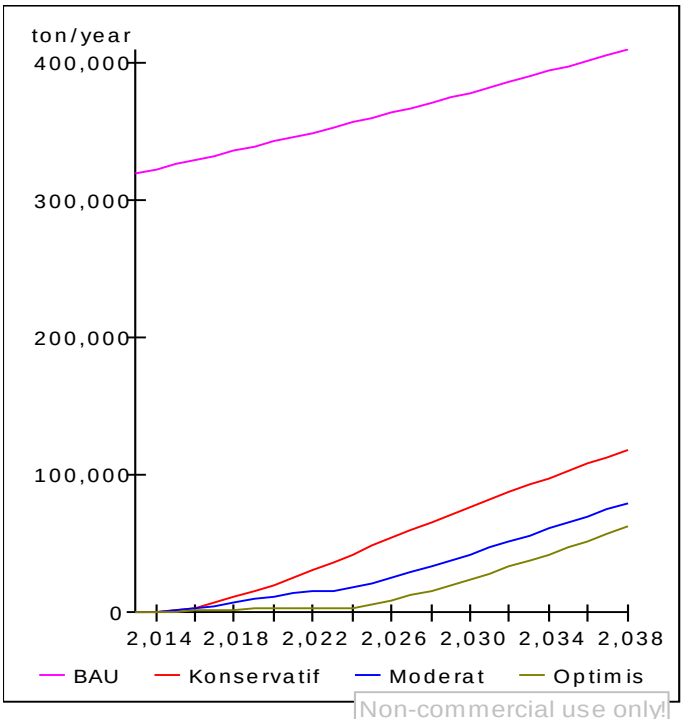

Figure 4. Scenario of Decreasing the Load of BOD Pollution through Household Waste Water Reuse

Utilization of waste water after processing or reclaim is an easy way to reduce the BOD pollution load. Processed wastewater can be used to water the garden or plants, water the street or yard and fire extinguishers [59]. Another designation of treated wastewater is for raw water drinking, injected into soil or ground water, agricultural irrigation, and other suitable designation. However, the waste water that is used is very small at 5% because some people do not want to use it by reason of environmental impacts and health risks [60], social cultural acceptance [61], even religion [23]. Therefore, it is necessary to raise awareness for the community to utilize treated wastewater. Awareness can be done by providing counseling. Scenario simulation results on the use of wastewater in optimistic conservative conditions according to Figure 3 shows that 5% of the community uses wastewater to watering the road or yard, 5% for watering the garden or plants and 3% for fire hydrants, while for reinjection into the ground or recharge well 0%.

Table 5. Scenario of Decreasing BOD Pollution Load through Household Waste Water Reuse

(ton/year)

year	BAU	Konservatif	Moderat	Optimis
2,013	319,441.73	0.00	0.00	0.00
2,014	322,645.73	0.00	0.00	0.00
2,015	325,881.86	1,331.00	1,064.80	479.16
2,016	329,150.46	3,740.15	2,859.02	1,120.50
2,017	332,451.84	7,015.33	5,124.47	1,715.50
2,018	335,786.33	10,978.87	7,666.15	2,141.97
2,019	339,154.27	15,482.30	10,340.53	2,928.97
2,020	342,555.98	20,401.81	11,459.40	2,638.28
2,021	345,991.82	25,634.43	13,857.59	2,468.69
2,022	349,462.12	31,094.82	15,014.88	2,702.64
2,023	352,967.22	36,712.51	15,804.52	2,965.86
2,024	356,507.48	42,429.53	17,831.46	2,592.55
2,025	360,083.25	48,198.50	21,562.20	5,443.11
2,026	363,694.89	53,980.89	25,471.99	8,625.27
2,027	367,342.75	59,745.65	29,537.89	12,111.73
2,028	371,027.20	65,468.00	33,738.01	15,872.93
2,029	374,748.60	71,128.37	38,051.70	19,878.25
2,030	378,507.33	76,711.59	42,459.59	24,097.05
2,031	382,303.76	82,206.16	46,943.74	28,499.35
2,032	386,138.26	87,603.58	51,487.59	33,056.41
2,033	390,011.23	92,897.90	56,075.97	37,741.04
2,034	393,923.04	98,085.22	60,695.11	42,527.88
2,035	397,874.09	103,163.39	65,332.55	47,393.52
2,036	401,864.77	108,131.63	69,977.11	52,316.59
2,037	405,895.47	112,990.29	74,618.82	57,277.72
2,038	409,966.60	117,740.66	79,248.87	62,259.55

Strategy of Household Wastewater Management

Based on the conditions of various scenarios and controlled input simulations, it can be illustrated the behavior conditions of each sub-model in the future. Sensitivity to scenarios is obtained from conservative variables. Comparison between conservative conditions and optimistic conservative and moderate conservative conditions can be seen in Table 6

Table 6. Variable Sensivity in Scenarios.

Simulation Variable	Konservative	Moderate	Optimistic
Reduction	379.122,26	372.964,56	368.992,22
Recycling	210.622,56	199.133,97	180.083,07
Reusing	117.740,66	79.248,87	62.259,55

Simulation Variable	Percentage		O/M
	Moderate	Optimistic	
Reduction	1,62	2,67	1,65
Recycling	5,45	14,50	2,66
Reusing	32,69	47,12	1,44
Sensitivity Value of O/M ratio			1,91

Based on the O / M ratio sensitivity value, the average value of 1.91 is obtained. The optimistic conservative condition should be

a concern in determining wastewater management policies, especially at the stage of wastewater treatment which has a value that is 2 times greater than moderate conservative conditions. Waste water treatment is more effective in reducing the BOD pollution load that will enter the environmental media compared to the reduction of wastewater and utilization or reuse of waste water.

Some of the problems in household wastewater treatment include: 1) relatively small capacity of WWTP, average 45 home connections and limited land, 2) WWTs performance is still low at 43.75% or can reduce BOD pollution load by 56.25%, and 3) wastewater treatment has not been carried out in an integrated manner.

Increased Capacity of WWTPs

The small capacity of WWTP is only able to process BOD pollution loads of 1.1826 tons / year per unit WWTP. As a result of the small capacity of WWTP, the processing of unprocessed BOD pollution load in 2017 amounted to 153,397.66 tons and the number of WWTPs was needed at 129,712 units and at the end of the simulation in 2038 needed 316,624 WWTP units. The increase in WWTP at the end of the simulation in 2038 amounted to 231.453 units so that there was a difference in the needs of WWTPs as many as 85,171 units.

According to the Directorate of PPLP Ministry of Public Works (2016), that the construction of WWTP anaerobic system with 50 home connection services requires land of 20 m^2. Limited land in urban areas resulted in WWTP facilities being built under road infrastructure or other public infrastructure.

Based on the projected needs and accretion of WWTP, another problem that will arise is the problem of operational and maintenance of WWTP facilities in the community. The results of research in the field show that up to 2017 the number of WWTPs that have been built is 131 units. Data obtained from the [62], showed that of the 131 units of WWTP that had been built, there were 60 units in good condition, 30 units were lightly damaged, and 37 units were severely damaged or not functioning. The data shows that 51.15% of WWTPs that have been built do not function properly physically, but the quality of the effluent produced is <10% which meets the quality standards of domestic wastewater.

The strategy that can be done to solve the problem of the large number of WWTPs needed and the addition of WWTPs and the number of WWTPs that are not functioning properly is to increase the capacity of WWTPs. As a comparison of the Losari WWTP as an urban WWTP with the number of house connections of 14.405 only able to process BOD pollution loads of 5,582.5 tons per year at the start of operations in 2021 and 12,696.51 tons per year after full operation in 2025. WWTP Losari only able to serve 2.974% of the population of Makassar City. Based on the description of Losari WWTP, to process all wastewater generated by residents of Makassar City, Indonesia, 34 WWTPs are needed. The operation and maintenance of WWTPs is 34 units if it is considered to be too heavy, so the WWTP capacity should be increased so that one unit of WWTP can serve 5% of the population of Makassar City, Indonesia. The number of WWTP units needed if the capacity can serve 5% of the population of Makassar City, then only 20 units of WWTP are needed but must also take into account the increase in pollution load due to the increase in population.

Effectiveness of WWTP Performance

The effectiveness of WWTP performance is influenced by several factors, among others: technology choices of WWTP, maintenance and operation of WWTPs. Based on observations in the field, the WWTP system that has been built in Makassar City is only one type, the anaerobic system. According to [41], that wastewater with high organic matter content can be processed with an anaerobic system.

According to [31] that WWTP can reduce BOD pollution load by 58%. This is not much different from the data obtained in this study that is equal to 56.25%. But it needs to be understood that the communal WWTPs that were sampled were the best WWTPs that were chosen purposively. According to [11], [63], [64], [65], [66], [67], that the septic tank is very good at maximum operation can reduce the BOD pollution load by 60%.

The strategy to maximize the performance of WWTPs to reduce pollution load can be done by: carrying out maintenance of WWTP on a regular basis, operating WWTP continuously so that the microorganisms contained in the reactor as breeding decomposers are not disturbed, avoiding waste water flow into the WWTP network containing ingredients chemicals that can kill microorganisms, such as cleaning agents or anti-septic substances, avoid flowing into the WWTP network of high-temperature wastewater. In addition, it is necessary to look for alternative WWTP systems or the construction of WWTPs in the future using a WWTP system that is different from the existing WWTP system. An example of WWTP system that needs to be applied to maximize the decrease in BOD pollution load is the trickling filter system. The trickling filter system combines anaerobes and aerobes, where wastewater is initially treated with an anaerobic system and wastewater is spread to the top surface of the media with the distributor's arm rotating and water dripping down through the media layer. According to [39], that wastewater from the food industry can be processed using trickling filters, the typical value of organic loads for trickling filters is 0.5 kg BOD5 per m^3 day. The characteristics of food industry wastewater have similarities with household wastewater containing high organic matter.

Integrated Waste Water Management

Based on the sensitivity values in Table 6, it shows that wastewater treatment is more effective in reducing BOD pollution load because it has a 2 times greater ratio between optimistic and moderate sensitivity values. The data in Table 1 also shows that wastewater treatment can reduce pollution loads by up to 41.1% but with integrated wastewater treatment with reduction of wastewater and reuse of wastewater can reduce the BOD pollution load to reach 71.28%.

Waste water treatment requires investment costs for the construction of WWTP infrastructure, in addition it requires routine and regular operational and maintenance costs. Reduction of wastewater and reuse of waste water does not require facilities and infrastructure or costs, only the willingness and awareness is needed to reduce the BOD pollution load that will enter the environmental media. Therefore, the strategy is to arouse and build public awareness through counseling to reduce waste water and reuse waste water that has been treated.

IV. CONCLUSION

Management of household wastewater must be a series of activities which include reducing, processing and reusing waste water. The simulation results show that the stages of wastewater treatment can reduce BOD pollution load by 41.1% and the ratio sensitivity value between optimistic and moderate conditions is 2 times greater but if done in an integrated manner between reducing, processing and reusing wastewater can reduce the BOD pollution load up to 71.28%.

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REFERENCES

[1] Wardhana, W.A., 2004. Dampak Pencemaran Lingkungan. Edisi Revisi. Yogyakarta: Penerbit Andi Yogyakarta, Indonesia.

[2] Sutton, P.M., H.Melcer, O.J. Schraa, A.P. Togna. 2011. Treating municipal wastewater with the goal of resource recovery. Water Sci. Technol., 63 (1): 25-31.

[3] Puchongkawarin, C., C.Gomez-Mont, D.C. Stuckey, and B.Chachuat. 2015. Optimization-based methodology for the development of wastewater facilities for energy and nutrient recovery. Chemosphere, 140: 150-158

[4] Alnahhala, S. and E. Spremberga. 2016. Contribution to Exemplary In-House Wastewater Heat Recovery in Berlin, Germany. Procedia CIRP, 40: 35 – 40.

[5] Van der Hoek, J.P., H. Fooij and A. Struker. 2016. Wastewater as a resource: Strategies to recover resources from Amsterdam's wastewater. Resources, Conservation and Recycling, 113: 53-64.

[6] Otis,R.J., N.J.Hutzler and W.C.Boyle. 1974. On-site household wastewater treatment alternatives: Laboratory and field studies. Water Research, 8(12): 1099-1113.

[7] Reungoat,J., B.I.Escher, M.Macova and J.Keller. 2011. Biofiltration of wastewater treatment plant effluent: effective removal of pharmaceuticals and personal care products and reduction of toxicity. Water Res., 45(9): 2751–2762.

[8] Sasimartoyo, T.P., 2002. Kajian Penerapan Sistem Eko-sanitasi dalam Pemanfaatan Kembali Limbah Manusia yang Terlupakan. Media Litbang Kesehatan Volume XII Nomor 1 Hal 6 – 11. Jakarta.

[9] Alvarez,J.A., E.Armstrong, M.Gómez and M.Soto. 2008. Anaerobic treatment flow-strength municipal wastewater by a twodstage pilot plant under psychrophilic conditions. Bioresour Technol., 99(15): 7051-7062.

[10] Richards,S., E.Paterson, P.J.A.Withers and M.Stutter. 2016. Septic tank discharges as multi-pollutant hotspots in catchment. Sci. Total Environ., 542: 854–863.

[11] Supriyatna, B., 2000. Pengelolaan Air Limbah yang Berwawasan Lingkungan Suatu Strategi dan Langkah Penanganannya. Jurnal Teknologi Lingkungan. Vol. 1 No.1 Tahun 2000 Hal. 17 – 26.

[12] Zavala, M.A.L., R.C. Vega and R.A.L. Miranda. 2016. *Potential of rainwater harvesting and greywater reuse for water consumption reduction and wastewater minimization*. Journal of Water, 8: 264 – 282.

[13] Kärrman,E. 2001. Strategies towards sustainable wastewater management. Urban Water, 3(1-2): 63-72.

[14] McCarty,P.L., J. Bae and J. Kim. 2011. Domestic wastewater treatment as a net energy producer—can this be achieved? Environ. Sci. Technol., 45: 7100-7106.

[15] Libralato,G., A.V.Ghirardini and F.Avezzù. 2012. To centralise or to decentralise: An overview of the most recent trends in wastewater treatment management. Journal of Environmental Management, 94(1): 61-68

[16] Lijó,L., S.Malamis, S.González-García, M.T.Moreira, F.Fatone and E.Katsou. 2017. Decentralised schemes for integrated management of wastewater and domestic organic waste: the case of a small community. Journal of Environmental Management, 203(Part 2): 732-740

[17] Zbontar, L. and P. Glavic, 2000. Total site: wastewater minimization: Wastewater reuse and regeneration reuse. Resources, Conservation and Recycling, 30(4): 261-275

[18] Wang, Y.P. and R. Smith, 1994. Wastewater minimisation Chemical Engineering Science, 49(7): 981-1006

[19] Bakir, H. A., 2001. Sustainable wastewater management for small communities in the Middle East and North Africa. *Journal of Environmental Management*, *61*(4): 319-328.

[20] Medilanski,E., L.Chuan, H.-J. Mosler, R. Schertenleib and T.A.Larsen. 2006. Wastewater management in Kunming, China: a stakeholder perspective on measures at the source. Environ. Urban, 18: 353-368.

[21] Orth,H. 2007. Centralised versus decentralised wastewater systems? Water Sci. Technol., 56: 259-266.

[22] Gross,A., N. Azulai, G. Oron, Z. Ronen, M. Arnold, A.Nejidat.2005. Environmental impact and health risks associated with greywater irrigation—a case study. Water Sci. Technol., 52 (8): 161-169

[23] Al-Hamaiedeh dan M. Bino, 2010. Effect of Treated Grey Water Reuse in Irrigation on Soil and Plants. Mutah University, Civil and Environmental Engineering Department, Jordan. Desalination 256 (2010) 115 – 119, Elsevier.

[24] Rahardjo, D., 2014. Bulletin Lingkungan Hidup Kalpataru. Badan Lingkungan Hidup Daerah Istimewa Yogyakarta.

[25] Al-Jayyousi, O. R., 2003. *Greywater reuse: towards sustainable water management*. Desalination, 156(1-3): 181-192.

[26] Halalsheh, M., 2008. Greywater characteristics and treatment options for rural areas in Jordan. Bioresours. Technol., 99 (4): 6635-6641

[27] Dixon, A., D. Butler and A. Fewkes, 1999. Water saving potential of domestic water reuse systems using greywater and rainwater in combination. *Water science and technology*, *39*(5): 25-32.

[28] Li, Z., F.Boyle and A.Reynolds. 2010. Rainwater harvesting and greywater treatment systems for domestic application in Ireland. Desalination, 260(1-3): 1-8.

[29] Haydar,S., M.Anis, G.Ehina, J.A.Aziz, dan M.Arbi. 2018. An innovative design of septic tank for wastewater treatment and its performance evaluation: An applicable model for developing countries. Chinese Journal of Chemical Engineering, 26(4): 886-891.

[30] Setiarini, A.N.F., Mursid Rahardjo, dan Onny Setiani, 2016. Evaluasi Kinerja Pengelolaan Air Limbah Domestik terhadap Tingkat Kekeruhan dan Kadar *Escherichia coli* dalam Air Tanah di Perumnas Gunung Kota Cirebon. Jurnal Kesehatan Masyarakat (e-Journal), Vol. 4, No. 2, Hal. 119 – 128.

[31] Samina, Onny Setiani, dan Purwanto, 2013. Efektivitas Instalasi Pengolahan Air Limbah (IPAL) Domestik di Kota Cirebon terhadap Penurunan Percemar Organik dan E-Coli. Volume 11, Issue 1, Hal. 36 – 42.

[32] Devi,R., R.P.Dahiya. 2008. COD and BOD removal from domestic wastewater generated in decentralized sectors. Bioresour Technol., 99(2): 344–349.

[33] Nenov, V., 1995. TSS/ BOD removal efficiency and cost comparison of chemical and biological wastewater treatment. Water Science and Technology, 32(7): 207-214.

[34] Oeller, H.J., Demel, I., and G. Weinberger., 1997. Reduction in residual COD in biologically treated paper mill effluents by means of combined ozone and ozone/UV reactor stages. Water Sci. Technol. 35 (2): 269–276.

[35] Franta,J.R. and P.A.Wilderer. 1997. Biological treatment of papermill wastewater by sequencing batch reactor technology to reduce residual organics. Water Sci. Technol. 35 (1): 129–136.

[36] Irfan,M., T.Butt, N.Imtiaz, N.Abbas, R.A.Khan, A.Shafique. 2017. The removal of COD, TSS and colour of black liquor by coagulation–flocculation process at optimized pH, settling and dosing rate. Arabian Journal of Chemistry, 10(Suppl.2): S2307-S2318

[37] Sugiharto, 1987. Dasar-Dasar Pengelolaan Air Limbah. Indonesia University Press. Jakarta.

[38] Ávila,C., J.J. Salas, I. Martín, C. Aragón, J. García. 2013. Integrated treatment of combined sewer wastewater and storm water in a hybrid constructed wetland system in southern Spain and its further reuse. Ecol. Eng., 50: 13-20.

[39] Asmadi dan Suharno, 2012. Dasar-dasar Teknologi Pengolahan Air Limbah. Gosyen Publishing. Yogyakarta.

[40] Hakanen,J., K. Sahlstedt and K. Miettinen. 2013. Wastewater treatment plant design and operation under multiple conflicting objective functions. Environmental Modelling & Software, Volume 46, 2013, pp. 240-249

[41] Said, N.I., 2003. Teknologi Pengolahan Air Limbah Secara Anaerob dan Aerob Menggunakan Biofilter. Badan Pengkajian dan Penerapan Teknologi. Jakarta.

[42] Al-Isawi, R., A.Sani, S. Almuktar, M. Scholz. 2015. Vertical-flow constructed wetlands treating domestic wastewater contaminated by hydrocarbons. Water Sci. Technol., 71: 938-946.

[43] Al-Isawi,R., S.Ray and M.Scholz. 2017. Comparative study of domestic wastewater treatment by mature vertical-flow constructed wetlands and artificial ponds. Ecological Engineering, 100: 8-18.

[44] Kurniawan, M.W., P. Purwanto, S. Sudarno, 2013. Strategi Pengelolaan Air Limbah Sentra UMKM Batik yang Berkelanjutan di Kabupaten Sukoharjo. Program Magister Ilmu Lingkungan, Universitas Diponegoro. Jurnal Ilmu Lingkungan Vol. 11 No. 2 Hal. 62 – 72.

[45] Afandi, Y.V., Henna Rya Sunoko, Kismartini, 2013. Status Keberlanjutan Sistem Pengelolaan Air Limbah Domestik Komunal Berbasis Masyarakat di Kota Probolinggo. Program Magister Ilmu Lingkungan, Universitas Diponegoro. Jurnal Ilmu Lingkungan Vol. 11 No. 2 Hal. 100 – 109.

[46] Prisanto, D.E., Bagyo Yanuwiadi, dan Soemarno, 2015. Studi Pengelolaan IPAL (Instalasi Pengelolaan air Limbah) Domestik Komunal di Kota Blitar, Jawa Timur. Program Magister Pengelolaan sumberdaya Lingkungan, Program Pascasarjana Universitas Brawijaya Malang. J-PAL Vol. 6 N0.1 Hal. 74 – 80.

[47] Baawain,M.S., M.Al-Jabri and B.S.Choudri. 2014. Characterization of Domestic Wastewater Sludge in Oman from Three Different Regions and Recommendations for Alternative Reuse Applications. Iran J. Public Health, 43(2): 168–177.

[48] Jhansi, S.C. and Santosh Kumar Mishra, 2013. Wastewater Treatment and Reuse: Sustainability Options. The Journal of Sustainable Development Vol. 10, Iss. 1, Pp. 1 – 15.

[49] Mourad,K.A., J.C. Berndtsson, R.Berndtsson. 2011. Potential fresh water saving using greywater in toilet flushing in Syria. Journal of Environmental Management, 92(10): 2447-2453

[50] Cipolla, S.S. and M.Maglionico. 2014. Heat recovery from urban wastewater: Analysis of the variability of flow rate and temperature. Energy and Buildings, 69: 122–130.

[51] Madungwe,E. and S.Sakuringwa. 2007. Greywater reuse: A strategy for water demand management in Harare? Physics and Chemistry of the Earth, Parts A/B/C, 32(15-18): 1231-1236.

[52] Misra,R.K., J.H. Patel, V.R. Baxi. 2010. Reuse potential of laundry greywater for irrigation based on growth, water and nutrient use of tomato. Journal of Hydrology, 386(1–4): 95-102

[53] Apostolidis , N., Chris Hertle and Ross Young, 2011. Water Recycling in Australia. Water journal Vol. 3, Hal. 869-881

[54] Baggett,. S, Jeffrey P, Jefferson B., 2006. Risk Perception in Participatory Planning for Water Reuse. Desalination 187: 149-158.

[55] Almeida,M.C., D.Butler and E.Friedler. 1999. At source domestic wastewater quality. Urban Wat. Journ., 1 (1): 49 – 55.

[56] Mara, D., 2004. Domestic Wastewater Treatment in Developing Countries. Earthscan Publishers in Assosiation with WWF-UK and the International Institute for Environment and Development.

[57] Vymazal,J. 2007. Removal of nutrients in various types of constructed wetlands, Sci. Total Environ., 380: 48–65.

[58] Parabang, S., Soemarno, Amin Setyo Leksono dan Andi Tamsil, 2019. Dynamic Model of Household Wastewater Management to Reduce the Pollution Load of Biological Oxygen Demend (BOD). International Journal of Scientific and Research Publications, Volume 9, Issue 6, 510-517.

[59] Idris-Nda, A., Humuani Kaka Aliyu, Musa Dalil, 2013. The challenges of domestic wastewater management in Nigeria: A case study of Minna, central Nigeria. International Journal of Development and Sustainability Volume 2 Number 2 (2013): Pages 1169-1182.

[60] WHO, 2006. Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume 2: Wastewater Use in Agriculture, Geneva, Switzerland.

[61] D'Andrea, M.L.G., Ariela GJ Salas Barboza, Valeria Garcés, María S Rodríguez Alvarez, Martín A Iribarnegaray, Viviana I Liberal, Graciela E Fasciolo, Jules B van Lier and Lucas Seghezzo, 2015. The Use of (Treated) Domestic Wastewater for Irrigation: Current Situation and Future Challenges. International Journal of Water and Wastewater Treatment Vol.1 No.2 Tahun 2015.

[62] UPTD PAL, 2017. Laporan Monitoring Instalasi Pengolahan Air Limbah di Kota Makassar. Unit Pelaâksana Teknis Dinas Pekerjaan Umum Pemerintah Kota Makassar. Makassar.

[63] Colares, C.J.G. And D.Sandri. 2013. Efficiency of sewage treatment with septic tanks followed by constructed wetlands with different support materials. *Revista Ambiente & Água*, *8*(1): 172-185.

[64] Sharma, M.K., A.Khursheed and A.A.Kazmi. 2014. Modified septic tank-anaerobic filter unit as a two-stage onsite domestic wastewater treatment system. *Environmental technology*, *35*(17): 2183-2193.

[65] Abusam, A., A.B. Shahalam, M.I. Ahmed and A. Mydlarczyk. 2015. Treatment of Septic Tank Effluent for Reuse as Irrigation water. Int. J. of Envir. Engineering, 2(1): 166-173.

[66] Anil, R. and A.L. Neera. 2016. Modified Septic Tank Treatment System. Procedia Technology, 24: 240-247.

[67] Abbassi, B., R. Abuharb, B. Ammary, N. Almanaseer and C.Kinsley. 2018. Modified septic tank: innovative onsite wastewater treatment system. *Water*, *10*(5): 578.

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