Public perception and contribution of domestic waste to water pollution of Lake Matano, South Sulawesi-Indonesia

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Abstract. Lake Matano, one of the deepest lakes on the earth, is an important lake in Indonesia in related to its economic, social and ecological implications. The lake has a variety of functions, including water resource for hydropower generating, the habitat of various aquatic organisms, and water sources for domestic purposes, as an area of fishing and fish culture in floating net cages, and tourist destinations. Therefore, Lake Matano receives an amount of pollution load from these activities. This study aims to determine the public perceptions and contribution of domestic waste to water pollution of Lake Matano. This research was conducted based on a survey, in which data collection techniques were complete by direct interviews with residents using questionnaires and direct observation of the condition of the surrounding community. The results showed that public perceptions of the water pollution of Lake Matano were due to tourism and increasing settlement in the area bordering the lake (floating house). The criteria for the action of water pollution in Lake Matano through domestic waste were still in good category.

Keywords: Public perception, Lake Matano, domestic waste.

1. Introduction
Lake Matano, one of the deepest lakes on the earth, is an important lake in Indonesia in related to its economic, social and ecological implications. Lake Matano has variety of functions, including water resource for hydropower generating, the habitat of various aquatic organisms, water sources for domestic purposes, as an area of fishing.

Lake Matano is not only a famous place for the locals but also a major attractive place for tourism and is considered as one of the world heritages. Thus, lake sustainability should be maintained for future generations. Disposal of domestic waste is noticeable issue in Lake Matano. At present, the condition of Lake Matano is threatened by abandoned garbage in certain places such as Ideas Beach which is known as tourism area. In addition, rapid population and newly built residential areas located on the lake bank can lead to the decreasing of water quality directly or indirectly.

Domestic waste is the waste produced during a domestic activity. Improver handling, storage and disposal of wastes are major causes of environmental pollution, which provides breeding ground for pathogenic organism and encourages the spread of infectious diseases. Domestic waste is accounted as the biggest pollution load contributor. The most common domestic waste is organic species in the form
of food scraps, human and animal feces. Other types of domestic waste are inorganic domestic wastes (i.e. plastics) as well as the use of detergents, shampoo, soap, bleaching, fragrance and other chemicals [1]. These types of waste are relatively difficult to degrade. If the quantity and intensity of domestic waste is still within normal limits, then the lakes themselves can do the purification process naturally either through chemical, physical or biological processes. Nevertheless, increasing the number and activity of the population causes an increase in the disposal of domestic waste so that the process of decomposing waste naturally becomes unbalanced. Research on how much impact domestic waste can contribute to water pollution on the lake of Matano has not been done. This study aims to determine the public perceptions and contribution on domestic waste to the water pollution of Lake Matano.

2. Materials and Methods
2.1. Location of the study area
This research was conducted in some villages bordering Lake Matano such as Nuha, Matano, Sorowako, Magani and Nikel in August 2016.

2.2. Research type and data collection method
This research was a survey with a cross sectional design. For selecting study area and respondent, we used purposive sampling techniques. Primary data were obtained through direct interviews using questionnaires and direct observation with residents. In addition, analysis of E. coli and total coliform was carried out using filtration method [2].

2.3. Measurement of Pollution Activities
The measurement of pollution activities was done according to [3]. Pollution activities were measured by looking at the answers given by respondents consisting of 8 questions with a total of 32 scores. Each question has 4 answer choices.

a. Choice of answers a is given score = 1
b. Choice of answers b is given a score = 2
c. Choice of answers c is given a score = 3
d. Choice of answers d is given a score = 4

The criteria for assessing the score of pollution action are carried out as follows:
The highest number of scores is 8 x 4 = 32 (100%)
The lowest score is 8 x 1 = 8 (10%)
Grading criteria = 4
Rating interval = 32/4 = 8 (10%)

Then, assessment criteria are:
a) Pollution action is said to be good if the respondents get score > 24 or above 75% of questions given.
b) Pollution action is said to be moderate if the respondents get score > 16 or 51% to 75% of questions given.
c) Pollution action is said to be bad if the respondents get score > 8 or 26% to 50% of questions given.
d) Pollution action is said to be very bad if the respondents get score <8 or 10% to 25% of questions given.

3. Results and Discussions
3.1 Socio-demographic characteristic of respondents
A total 31 sampled households responded to the survey questionnaire. The sex of the respondents was more female respondents than male, with 61. It showed that female and male were 29 and 38.71, respectively (table 1). The modal age of the respondents was 40-49 years with 32.26% of respondents
being in this age group. Nearly half (45.16%) of the respondents had senior education level, 19.35% attained a Junior high school, 25.81% had basic educational level and 9.68% had college/university level. Respondents with higher education and income tend to have greater water environmental concern. The main predictor of concern about the water environment was educational status [4]. Increment age, income and education could be the main predictors of concern about water pollution [5].

| Variables                  | Frequency (N=31) | Percent (%) |
|----------------------------|------------------|-------------|
| Sex                        |                  |             |
| Male                       | 12               | 38,71       |
| Female                     | 19               | 61,29       |
| Age (years)                |                  |             |
| 20-29                      | 5                | 16,13       |
| 30-39                      | 9                | 29,03       |
| 40-49                      | 10               | 32,26       |
| 50-59                      | 6                | 19,35       |
| 60 and above               | 1                | 3,23        |
| Level of education         |                  |             |
| Primary school             | 8                | 25,81       |
| Junior high school         | 6                | 19,35       |
| Senior high school         | 14               | 45,16       |
| College/University         | 3                | 9,68        |

3.2 Respondents' Behavior in Disposing Domestic Waste and Utilizing Materials that Potentially Reduce Lake Water Quality

Humans as living beings are equipped with common sense and mind to control their behavior according to their necessity. Notoatmojo (1985) in [1] stated that there are three types of behaviors, namely: (a). behavior in the form of knowledge; (b) attitudes and (c). action. In this study we investigated about respondents' Behavior in disposing domestic waste and utilizing materials that potentially reduce lake water quality. Based on the results of the study, it was found that 96.77% of respondents had heard of LAW No. 23 of 1997 on environmental management. Even though based on further interviews, it was found that respondents' knowledge of the regulation was poor. None of the respondents knew the overall contents of Law No. 23 of 1997. However, the respondents' knowledge about the definition of household wastewater was adequate, more than half of respondents (70.97%) defined household wastewater as all waste from either kitchen or bathroom. From the results of the study, it was known that respondents used materials that had the potential to reduce the lake water quality, namely detergents (solid, powder, liquid, and cream), soap and bleaching material (table 2).
Table 2. Respondents' Behavior in Disposing Domestic Waste and Utilizing Materials which Potentially Reduce the Lake Water Quality

| Variable | Frequency (N=31) | Percent (%) |
|----------|------------------|-------------|
| Do know about UU The Indonesian Environmental Law | | |
| Yes | 30 | 96.77 |
| No | 1 | 3.23 |
| Definition of household waste | | |
| Yes | 22 | 70.97 |
| No | 9 | 29.03 |
| Polluted environmental impacts | | |
| Cause a disease | 31 | 100 |
| Do not cause disease | 0 | 0 |
| The type of laundry detergents used by respondents | | |
| Solid | 0 | 0 |
| Liquid | 1 | 3.23 |
| Powder | 30 | 96.77 |
| Cream | 0 | 0 |
| Consumption of Clothing Bleach by Respondents | | |
| yes | | |
| No | 12 | 38.71 |
| Rarely | 19 | 61.29 |

Detergents is one of the main sources of phosphate pollutants in the waters. Phosphate can be derived from detergents and pesticides from agricultural activities [6]. Detergents are generally referred to synthetic compounds that contain an active agent called as surfactant. Surfactant has hydrophilic and lipophilic functional groups that emulsify the oily matter and keep the fabric wet and the soil in suspension. Apart from surfactants, another substance called builder is added to detergents to increase efficiency. Phosphate in the form of sodium tri-poly phosphates (STPP) is the most used builder which forms complexes with Ca$^{2+}$ and Mg$^{2+}$ ions creating a favorable condition for detergent action by reducing hardness of water. Laundry detergents generally contain more than 40% STPP ($\text{Na}_5\text{P}_3\text{O}_{10}$). P content in STPP detergent is 25.27%. Furthermore, detergent P as STPP when released together with laundry wastewater is quickly hydrolyzed into orthophosphate which known to cause bad impacts on the quality of aquatic ecosystems and induces eutrophication (algae blooms, kills fish and poor water quality) [7].

The data in Table 3 provide information regarding the type of the detergent being used by the respondents. The data shows that the largest percentage (96.77 %) of the respondents used detergent powder for washing of clothes compared to any other type detergent. The powder detergents were most widely detergent that purchased and used as cleaning agents [8]. Powder detergents for washing clothes adds more chemical contamination of water compared to liquid detergents. The higher level of pH, total dissolved solids (TDS), chloride, sulphate, carbonate and in washing water with the use of detergent powder due to the excessive use of filler and builders in preparation of these detergents. These finding suggest that to save water environment, it is better to use liquid detergents than of detergents powder [9].
Winata et al, 2000 in [1]) suggested that bleaching materials contribute to the presence of phenol in waters. Phenols are known to be toxic and inflict both severe and long-lasting effects on both humans and animals. They act as carcinogens and cause damage to the red blood cells and the liver, even at low concentrations. Interaction of these compounds with microorganisms, inorganic and other organic compounds in water can produce substituted compounds or other moieties, which may be as toxic as the original phenolic compounds [10]. The 2-nitrophenol and 4-nitrophenol are the reaction products between phenol and nitrite ions in the aquatic environment which catalyzed by ultraviolet radiation from the sun [11]. Nitrophenols was identified to be the microbial degradation product of nonylphenol polyethoxylaes under anaerobic conditions [12].

Table 3 indicates that more respondents did not pollute the lake directly with detergents when washing the clothes (54.84%), teeth brushing (87.10%), washing the dishes (74.19%), disposal oil/fat (77.42%), and disposal of the oil vehicles (100%). The pollution through solid waste shows that 100% of respondents did not dispose of garbage into the lake, and nearly 90.32% of respondents treated plastic waste by collecting and throwing it into a garbage dump and 90.32% of respondents did not carry out defecation/urinate into the lake waters.

| Variable                        | Frequency (N=31) | Percent (%) |
|---------------------------------|------------------|-------------|
| Washing the clothes            |                  |             |
| Every day                       | 3                | 25.80       |
| > three times a week            | 0                | 3.23        |
| < three times a week            | 6                | 16.13       |
| Never                           | 22               | 54.84       |
| Teeth brushing                  |                  |             |
| Every day                       | 2                | 9.68        |
| > three times a week            | 0                | 0.00        |
| < three times a week            | 1                | 3.22        |
| Never                           | 28               | 87.10       |
| Washing the dishes              |                  |             |
| Every day                       | 4                | 16.13       |
| > three times a week            | 0                | 0           |
| < three times a week            | 0                | 9.68        |
| Never                           | 27               | 74.19       |
| The oil/fat disposing           |                  |             |
| Every day                       | 1                | 6.45        |
| > three times a week            | 0                | 6.45        |
| < three times a week            | 0                | 9.68        |
| Never                           | 30               | 77.42       |
| The oil vehicle disposing       |                  |             |
| Every day                       | 0                | 0.00        |
| > three times a week            | 0                | 0.00        |
| < three times a week            | 0                | 0.00        |
| Never                           | 31               | 100.00      |
| Solid waste disposing           |                  |             |
Variable | Frequency (N=31) | Percent (%)
--- | --- | ---
Every day | 0 | 0.00
> three times a week | 0 | 0.00
< three times a week | 0 | 0.00
Never | 31 | 100.00

**The treatment of plastic waste**

| Activity | Frequency (N=31) | Percent (%) |
| --- | --- | --- |
| Throwing directly to the lake | 0 | 0 |
| Throwing in the edge of the lake | 0 | 0 |
| Burning in the edge of the lake | 22 | 9.68 |
| Collecting | 9 | 90.32 |

**Defecation/urinate**

| Frequency | Percent (%) |
| --- | --- |
| Every day | 9.68 |
| > three times a week | 0 |
| < three times a week | 0 |
| Never | 30 | 90.2 |

Water pollution of Lake Matano is inseparable from the acts of litter/discharge carried out by the surrounding community including domestic waste. Water pollution caused by washing activities in the lake is the presence of residual rinses containing detergents which directly flow into the lake. As can be seen in Table 3 that only 16.3% of respondents did washing dishes on the lake. Nevertheless, washing activities especially washing dishes on the lake can pollute the lake water not only because of the detergent used to wash but also because of the leftovers, fats and oils that are also carried away to the lake water body.

The action of the community that causes water pollution of lake not only from washing clothes and dishes, bathing or brushing teeth, but also because of the habit of throwing garbage directly into the lake and defecation activities by some people directly on the lake water body. Based on the results of the study, 100% of respondents did not dispose of garbage into the lake and did not carry out defecation activities on the lake waters. In general, it can be said that the act of community pollution towards Matano lake was still in a good category (table 4).

| The Pollution Criteria | Frequency (N=31) | Percent (%) |
| --- | --- | --- |
| Very bad | 0 | 0.00 |
| bad | 0 | 3.23 |
| moderate | 3 | 6.45 |
| good | 28 | 90.32 |
| **Total** | 31 | 100.00 |

However, it was known that domestic waste discharged into lakes contains solid and liquid waste with several main properties including bacteria, which can cause disease transmission, containing organic matter and suspended solids. Therefore, the Biological Oxygen Demand (BOD) was usually high, containing organic and inorganic solids which settle in bottom of the water and cause low Dissolved Oxygen (DO), contain floating material in the form of suspense thereby reducing comfort and inhibiting the rate of photosynthesis [13]. Based on the results of the laboratory tests, the densities of bacteria in water samples, especially total coliform and E. coli at several points in Lake Matano, showed the same results with the respondent’s statement that they did not do defecation/urination.
activities on the Lake. The density of $E. \text{coli}$ and coliform bacteria in several regions of Lake Matano showed a fairly low range of 0-28 colonies/100 mL and 0-191 colonies/100 mL, respectively. The highest total coliform density was obtained in the Sorowako area, that is equal to 191 colonies/100 mL. The lowest coliform density was obtained in Nuha area of 17 colonies/100 mL (figure 1).

Figure 1. $E. \text{coli}$, coliform and total coliform bacteria in several village in Lake Matano

Sorowako Village has the largest population of 9,681 people and the lowest is Nuha Village with a population of 566 people (figure 2) [14]. Therefore, it is not surprising that the highest coliform density (191 colony/100 mL) was found at Sorowako.

Figure 2. Total population in villages around Lake Matano [14].

The results show different distribution of the density of $E. \text{coli}$ bacteria, where the Matano Village contain the highest density of $E. \text{coli}$, which was 28 colonies/100 ml, and Nuha Village contain the lowest density (1 colonies / 100 mL). Based on direct observations in the field, it was not surprisingly that Matano Village has a high density of $E. \text{coli}$. It was found a big urban drainage in the Matano Village is used for receiving household waste that are connected into the lake water body. Besides of that, the settlements located in the lake bank are also quite a lot in this region. It is suspected that this
settlement has been discharge their wastewater directly into the lake. Based on the results of the interviews with residents who living in those area, almost 90% of them did not have septic tank. Coliform bacteria are indicators of environmental contamination or poor sanitation, while E. coli is an indicator of fecal contamination from humans and warm-blooded animals. E. coli bacteria is one type of coliform bacteria found in many waters. The high total coliform and E. coli bacteria were observed, it seemed related to the domestic waste discharging into the waters [15]. Domestic water for hygiene and sanitation purposes must contain no E. coli colonies/100 mL and densities of total coliforms not more than 50 colonies/100 mL [16]. It suggested that the waters of the Lake Matano were not safe for using as a domestic water source for hygiene and sanitation purposes.

Different results between the survey results and coliform analysis data were probably caused by respondents who did not carried out of washing, bathing or other domestic activities on the lake directly. In fact, the respondents generally disposed of wastewater from household wastewater through drainage which connected to the lake and causes lake water pollution. In addition, the community believes that immensely tourism activity and widespread settlement in the area bordering the lake (floating house) in Lake Matano is potentially threatened the sustainability of Lake Matano waters.

4. Conclusion
Based on the results of a research on community perceptions and pollution which has been done on the Lake Matano, the obtained conclusions as follows:
1. The criteria of the Matano community pollution action through domestic waste on Lake Matano are still in the good category.
2. The pollution of Lake Matano according to public perception is caused by enormous tourism activity and increasing settlement in the area bordering the lake (floating house).

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Acknowledgments
First and foremost, I wish to thank Dr. Cynthia Henny dan Dr. Lukman for the support and guidance to do this research. I would like to thank Research Centre for Limnology for supporting and granting us research opportunity.