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Regional Case Study

Health Risk Analysis of Detergent Contamination in Communities on Kodingareng Lompo Island, Makassar City

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Abstract

Domestic activities in coastal and island communities are one of the factors that can affect the quality and quantity of traditional well water availability. One of the parameters of household wastewater is detergent pollutants. This study aimed to analyze the risk of detergent contamination in drinking water in the community of Kodingareng Lompo Island. This research is a type of quantitative research with a descriptive approach. The method used is the Environmental Health Risk Assessment (EHRA) approach. Based on the examination conducted, the highest concentration was found in drinking water samples 4 and 5, which was equal to 2.98 mg/l. While drinking water sample 2 has the lowest concentration of detergent contamination, which is 0.005 mg/l. The respondents' daily drinking water intake rate is < 2 L/day, 2 L/day and ≥ 2 L/day, with the highest percentage of 31.1% for consumption of 2 L/day. The frequency of detergent exposure in drinking water consumed by respondents, namely > 350 days/year, with a percentage of 84.4%. The most extended duration of exposure, namely 31 - 60 years, with a ratio of 64.4%. The results of ARKL calculations conducted on the concentration of detergent contamination in drinking water showed a high level of risk (RQ > 1) in three respondents and were classified as unsafe for drinking water consumption.

Keywords: Detergent; drinking water; health risk assessment; island communities

1. Introduction

The availability of water, which is part of a natural phenomenon, is often difficult to regulate and predict accurately (Najah Ahmed et al., 2019; Yu et al., 2018). The need for human water at this time and in the future will continue to increase and be sustainable. That is caused by the increasing number of people who require water (Flörke et al., 2018; Gebremeskel Haile et al., 2019; Hoekstra et al., 2018). According to the World Health Organization (WHO), the world's population in countries such as the UK, Singapore, and Australia has met their drinking water needs by 95%. The Indonesian people's coverage that has fulfilled drinking water needs has reached 85% (Agustina et al., 2019). The index of contamination of drinking water sources in small islands of Makassar City came from wells obtained

from moderately polluted water sources (Jacob and Sandjaya, 2020; Surya et al., 2020), namely two wells on Barrang Caddi Island, five wells on Kodingareng Lompo Island, three wells on Bone Tambung Island. and four wells on Lae-lae Island (Syamsir et al., 2019). Domestic activities of communities on the coast and islands are one of the factors that can affect the quality and quantity of groundwater availability. For example, using detergents cannot be separated from people's daily lives, such as washing activities that produce liquid waste (Yates and Evans, 2016). Several studies have examined the quality of water bodies in terms of detergent pollutant parameters in Indonesia (Brontowiyono et al., 2022; Dsikowitzky et al., 2020).

One of the parameters of household liquid waste is detergent pollutants. Detergents contain several main components, namely surfactants, such as Linear Alkylbenzene Sulfonate (LAS) and Alkyl Benzene Sulfonate (ABS). LAS is included in the category of anionic surfactants, which are more readily biodegradable than ABS (Chowdhury et al., 2021; Zhu et al., 2022). LAS contamination (as a detergent surfactant) in drinking water, which is corrosive and toxic (poisonous), is hazardous if swallowed by humans. LAS can cause severe and permanent damage to the digestive tract, burns to the digestive tract, vomiting, diarrhoea with blood, and asphyxia from a swollen throat (Zhou et al., 2018). The use of detergents can be an environmental problem due to their excessive and uncontrolled use. Vulnerability to detergent contaminants needs serious attention. Therefore, the balance of the ecosystem is maintained. On small islands with a minimal supply of shallow groundwater, groundwater as raw water for drinking water, either with treatment or without treatment, still leaves detergent content before consumption (Adicita et al., 2021, 2020; Apritama et al., 2020). That will be a severe health problem for people on small islands. So proper control and management efforts must be made to maintain the sustainability of the quality of the groundwater (Bodrud-Doza et al., 2020; Septiariva and Suryawan, 2021). One of the small islands in Makassar City with a relatively dense population is Kodingareng Lompo Island. This island is located in Sangkarrang District, Makassar City, with 14 ha. This island's source of clean water comes from groundwater through wells. The community uses the drilled wells on Kodingareng Lompo Island as a source of clean water and for daily activities. Along with the increase in population each year, groundwater use is also increasing. In addition to increasing groundwater extraction, climate change is also indicated as one of the causes of the clean water crisis in small islands. The availability of clean water and drinking water for the people of Kodingareng Lompo Island is still vulnerable to problems of scarcity and pollution. The wells on this island are highly dependent on rainfall. The long dry season is the impact of climate change on water availability. The increased air temperature caused by climate change causes faster evaporation, causing groundwater to decrease (Corwin, 2021; Riedel and Weber, 2020).

Limited groundwater, the physical condition of wells that do not comply with health standards, and the distance of pollutant sources such as washing wastewater adjacent to wells have the potential for detergent concentrations to contaminate healthy water. That shows that the people of Kodingareng Lompo Island are very vulnerable to environmental health risks. Therefore, researchers are interested in researching health risk analysis of detergent contamination of the people of Kodingareng Lompo Island to help program planners, researchers, and experts to examine the causes and effects of a problem in the availability of cleaning water and drinking water on small islands to find solutions so as not to have a significant impact.

2. Methods

This research is a type of quantitative research with a descriptive approach. The method used is the Environmental Health Risk Analysis (ARKL) approach. The ARKL approach consists of several risk analysis steps: hazard identification, exposure analysis, dose-response analysis, and risk characterization assessment (Wahyuni et al., 2018). Detergent contamination is risky if the RQ (Risk Quotient) value > 1 and not difficult if the RQ value is 1. Calculations for non-carcinogenic intake (ingestion) use the following equation:

$$Ink = \frac{C \; x \; R \; x \; f_E \; x \; D_t}{W_b x \; t_{avg}} \quad (1)$$

Calculation of the level of non-carcinogenic risk

$$RQ = \frac{Ink}{R_f D} \quad (2)$$

Calculation of safe concentration:

$$Cnk(safe) = \frac{RfD \; x \; Wb \; x \; t \; avg}{R \; x \; fE \; x \; Dt} \quad (3)$$

Calculation of the amount of safe consumption:

$$Rnk(safe) = \frac{RfD \; x \; Wb \; x \; t \; avg}{C \; x \; fE \; x \; Dt} \quad (4)$$

Where:

RQ = Risk Quotient (non-carcinogenic risk level) (j)
Ink = Intake (intake), the amount of risk agent received by the individual per body weight per day (mg/kg/day) non-carcinogenic
R_fD = Reference Dose (reference value) (mg/kg/day)
Dt = Duration of exposure (years)
Wb = Body weight (kg)
t_{avg} = Average period (70 years for cancer effect and 30 years for non-cancer effect)
C = Concentration of pollutant (mg/kg) or (mg/l)
R = Amount of Intake (rate)

The study was conducted in June - August 2018 on Kodingareng Lompo Island, Ujung Tanah District, Makassar City. The collection of healthy water as a sample was carried out by purposive sampling, totalling 11 samples of drilled healthy water. The procedure for testing water samples is based on the standard method (Chen et al., 2020; Hollender et al., 2019) how to test anionic surfactant levels using a spectrophotometer using the methylene blue method at the Central Health Laboratory (BBLK) Makassar City. The data is processed and presented in the form of tables and narratives.

Data was collected using a random sampling technique in Kodingareng Lompo Island, Ujung Tanah District, and Makassar City. Random sampling is a technique in which all individuals in the population, either individually or collectively, are given the same opportunity to be selected as sample members. The number of samples used in this study was 45 people. Previous research has been carried out on small islands in Indonesia, such as Pari Island (Putranto, 2018) and Jambu Island (Saputri et al., 2021; Syafriani and Saputri, 2020).

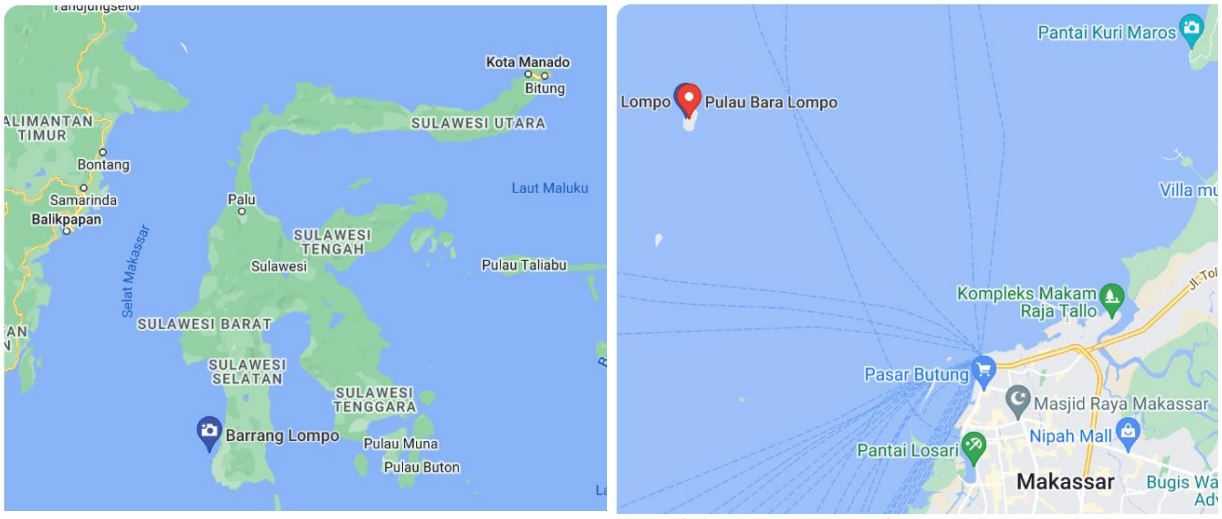

Figure 1. Study location (Google map, 2021)

3. Result and Discussion

The drinking water sample is based on healthy water consumed by the community as a source of drinking water. Therefore, detergent contamination was present in all water samples studied. Based on the examination, the highest concentration was found in drinking water samples 4 and 5, which was 2.98 mg/l. While drinking water sample 2 had the lowest detergent contamination concentration, 0.005 mg/l (Table 1). Measurements of daily drinking water intake, frequency of exposure to detergents in drinking water, duration of exposure to detergents in drinking water, and body weight of respondents were measured using the ARKL method (Table 2). The respondents' daily drinking water intake rate was < 2 L/day, 2 L/day, and 2 L/day, with the highest percentage amounting to 31.1% for consumption of 2 L/day. The frequency of exposure to detergents in drinking water consumed by respondents is > 350 days/year, 84.4%. The most extended duration of exposure is 31-60 years, with a percentage of 64.4%.

Table 1. Results of detergent concentration measurements in well drinking water samples on Kodingareng Lompo island

No.	RW	Detergent Concentration (mg/L)
1	1	0.44
2	1	0.005
3	1	0.71
4	2	2.98
5	2	2.98
6	2	0.005
7	3	1.36
8	3	0.04
9	4	2.88
10	5	0.23
11	6	2.91

Table 2. Results of measurement of drinking water intake rate, frequency of detergent exposure, duration of exposure, and respondents body weight on Kodingareng Lompo island

Variable	Frequency
Drinking-Water Intake Rate (L/day)	
< 2	27
2	14
≥2	4
Exposure Frequency (days/year)	
300	0
301 - 350	7
> 350	38
Exposure Duration (years)	
10 – 30	9
31 – 60	29
61 - 90	7
Weight (kg)	
35 – 45	16
46 – 55	18
56 – 65	7
66 – 75	4

Measurement of intake for detergent consumption was carried out on all respondents (Table 3). One of the respondents (respondent number 4) has a body weight of 39 kg, the drinking water intake rate is 3 L/day, and the frequency of exposure is 360 days/year with a detergent concentration in drinking water of 2.98 mg/l. The duration of exposure is 70 years. The amount of detergent in the

respondent's drinking water at 30 years of exposure (non-carcinogenic effect) is 0.52754 mg/kg/day (based on equation 1).

Table 3. Calculation value of intake for drinking water consumption of respondents in Kodingareng Lompo island

No.	Respondent	C	R	F_E	D_t	W_b	t_{avg}	Ink
1	R1	0.44	3	360	70	39	10950	0.07789
2	R2	0.005	2	362	32	48	10950	0.00022
3	R3	0.71	2	362	30	55	10950	0.02561
4	R4	2.98	3	360	70	39	10950	0.52754
5	R5	2.98	2.8	365	72	40	10950	0.50064
6	R6	0.005	2	330	15	75	10950	0.27400
7	R7	1.36	2	363	42	39	10950	0.09710
8	R8	0.04	1	351	36	51	10950	0.00090
9	R9	2.88	1	360	70	59	10950	0.11233
10	R10	0.23	1	359	32	45	10950	0.00536
11	R11	2.91	3	365	69	40	10950	0.50197

The risk level (RQ) in people who consume water The reference dose (RfD) for detergents through oral exposure (ingestion) according to the US-EPA in 2006 is 0.5 mg/kg/day. In the calculation of intake of the respondent (respondent number 4), the level of risk can be calculated using equation 2 with a value of 1.0551. Therefore, respondent number 4 has an RQ value of 1.0551 (RQ 1) for the risk of non-carcinogenic diseases. Based on the level of risk, it can be concluded that detergent residue in drinking water with a concentration of 1.28088 mg/l is classified as an unsafe or non-carcinogenic risk for public health. In addition, the value of RQ 1 was found in respondents 5 and 11 (Table 4).

Table 4. Value of risk level calculation results (RQ) on respondents consuming well water on Kodingareng Lompo island

No.	Responden	Ink	RfD	RQ
1	R1	0.07789	0.5	0.1558
2	R2	0.00022	0.5	0.0004
3	R3	0.02561	0.5	0.0512
4	R4	0.52754	0.5	1.0551
5	R5	0.50064	0.5	1.0013
6	R6	0.27400	0.5	0.0001
7	R7	0.09710	0.5	0.1942
8	R8	0.00090	0.5	0.0018
9	R9	0.11233	0.5	0.2247
10	R10	0.00536	0.5	0.0107
11	R11	0.50197	0.5	1.004

The calculation of the average RQ was 0.3363 mg/l (Table 5). The results of this calculation indicate that, on average, the respondents are not at risk of detergent exposure. However, all conditions must be maintained so that the RQ value does not exceed the number 1. The RQ value of each respondent is different because it is influenced by the respondent's consumption rate, exposure time, frequency of exposure, duration of exposure, body weight, and the average daily period.

Table 5. Risk level of respondents consuming well water

Information	RQ
Maximum	1.0551
Minimum	0.0001
Average	0.3363

Risk management or risk management needs to be carried out if the risk assessment results determine a risk agent's risk level in an unsafe or unacceptable condition in a particular population with several steps. The value of the safe concentration for consumption (non-carcinogenic effect) for each respondent at high risk can be seen in Table 6. The calculation results obtained an average for the safe concentration of detergent in drinking water in adults with an average body weight of 39 .6 kg, equal to or below ≤0.040678 mg/l. The safe concentration for detergent in a one-milligram litre of water needed by Respondent 4 is similar to or below ≤ 0.040349 mg/l to avoid the risk of non-carcinogenic diseases.

Table 6. Value of calculation of safe concentration (C) in high-risk respondents

No.	Respondent	RfD	Wb	Tavg	R	tE	fE	Dt	Cnk (safe)
1	R3	0.5	39	10950	3	70	360	70	0.040349
2	R4	0.5	40	10950	2.8	72	365	75	0.039683
3	R11	0.5	40	10950	3	69	365	69	0.042008

The results of the calculation of safe consumption can be seen in Table 7. The average amount of safe consumption (R) for high-risk respondents is equal to or below ≤2.876 L, with an average respondent's weight of 39.6 kg.

Table 7. Value of calculation of total safe consumption (R) in high-risk respondents

No	Respondent	RfD	Wb	Tavg	C	fE	Dt	Rnk (safe)
1	R1	0.5	39	10950	2.98	360	70	2.8434
2	R2	0.5	40	10950	2.98	365	75	2.7964
3	R3	0.5	40	10950	2.91	365	69	2.9882

The results of the risk level assessment in this study indicate that the detergent concentration of the respondents' drinking water has exceeded the maximum required limit and is at high risk for three respondents (RQ 1). That is because the risk assessment study does not only examine a risk agent (detergent) that has exceeded the required limits, which will directly affect human health. However, the risk assessment in this study examines exposure to detergents through specific exposure routes (oral/ingestion) by considering activity patterns and human anthropometric measurements. Exposure to these detergents was compared with a reference dose (RfD of detergent = 0.5 mg/kg/day) to estimate the magnitude of future risk.

On average, the detergent content in well water used by the community for drinking water consumption is 0.696 mg/l. Based on this research data, the well water used by the community for drinking water has exceeded the quality standard set by the government. Therefore, drinking water sources containing detergent concentrations are feared to affect human health. The results of this study indicate that there are three respondents whose RQ calculation results are more than 1. That can pose a health risk, so risk management is needed, including safe concentrations and the amount of safe consumption. The risk management calculation showed that the average safe concentration (C) and the amount of safe consumption (R) for respondents with high-risk characteristics were 0.040678 mg/l and 2.876 L/day, respectively.

Based on calculations, the average RQ value of respondents who consume well water daily is still less than 1 (RQ < 1). However, this needs to be a concern considering the current condition of respondents showing a health risk, and it needs to be taken seriously. The results of this study can

provide initial information for policymakers in Kodingareng Lompo Island to manage the risk as small as possible. An increase in intake that exceeds the RfD will undoubtedly increase the level of risk. The story of risk that exceeds one will significantly cause non-carcinogenic effects in humans. Health risks that result from repeated exposure to detergents contained in drinking water are non-carcinogenic (Emenike et al., 2020), such as diarrhoea, suppression of weight gain, increase in the relative weight of the liver, changes in body weight, changes in enzyme parameters (ATP, LDH, G6P enzymes) and serum biochemicals. Mild degeneration, desquamation of the tubular epithelium in the kidney, and others. At the same time, the risk of carcinogens from repeated exposure to detergents was not found.

The higher a person's weight, the lower the intake and the RQ value obtained. Someone with a low body weight will easily experience toxicity than someone with increased body weight (Nekhoroshkov et al., 2021; Rivai et al., 2021). In other words, the higher a person's weight, the smaller the risk of suffering from non-carcinogenic diseases. The increased distribution of detergent content in well water is due to polluted and household waste. The high load of detergent pollution is caused by domestic waste that enters the environment/drainage system without prior treatment and flows directly into the coastal and marine environment (Dey et al., 2021). This show that people living in coastal areas also contribute to the burden of pollution from domestic waste that is disposed of directly into drainage channels (Adicita et al., 2020; Bempah et al., 2022). The large concentration of detergent pollutants will negatively impact the two aquatic ecosystems that receive it.

This study's health risk estimates were calculated based on intake in drinking water sources. However, using healthy water for other consumption needs such as cooking can also increase health risks for non-carcinogenic effects. In this study, about 33% of residents still used well water without being treated for cooking needs, so calculating the risk of all exposure to detergents through oral (ingestion) is essential. High detergent surfactant content and exceeding the detergent MBAS limit value in water is one of the causes of eutrophication. Eutrophication is water pollution caused by the emergence of excess nutrients into the aquatic ecosystem. Eutrophication in marine ecosystems is caused by detergents containing phosphate, which is also influenced by pH, salinity, and temperature. One form of eutrophication is algae bloom, water hyacinth growth, and algae bloom explosion (Afifah et al., 2020; Koko et al., 2022; Sarwono et al., 2022; Suryawan et al., 2021).

4. Conclusions

The results of the examination of the detergent content in 11 samples of drinking water from wells showed the highest concentration of detergent was 2.98 mg/L, and the lowest concentration was 0.005 mg/L. The average detergent content in well water used by the community for drinking water consumption is 0.696 mg/L. This concentration has exceeded the quality standards set by the government through PERMENKES No. 492 of 2010 concerning Drinking Water Quality Requirements, which is below 0.05 mg/L.

The results of the health risk analysis of people who consume well water daily (Risk Quotient/RQ) show that three respondents are at health risk and are classified as unsafe for drinking water consumption. The calculation of the average RQ is 0.3363 mg/L. The results of this calculation indicate that, on average, the respondents are not at risk of exposure to detergents. However, all conditions must be maintained so that the RQ value does not exceed the number 1. The RQ value of each respondent is different because it is influenced by the respondent's consumption rate, exposure time, frequency of exposure, duration of exposure, body weight, and the average daily period. Risk management was conducted by reducing the high level of risk (RQ > 1) in 3 respondents by decreasing the safe concentration (Cnk) and the amount of safe consumption (Rnk). The results of the risk management calculation on the average safe concentration (C) and the amount of safe consumption (R) were 0.040678 mg/L and 2.876 L.

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