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PHYSICAL WATER QUALITY CONTAMINATED BY SOIL-TRANSMITTED HELMINTHS IN SUMBERSARI DISTRICT, JEMBER REGENCY

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Abstract

Introduction: *Soil-Transmitted Helminth (STH) or worm infection is an infection caused by intestinal nematode worm group that can be infectious through the soil medium. One straightforward transmission route is through contaminated water consumption as water is needed daily. This study aims to know the association between quality of physical water and STH contamination in the Sumbersari District, Jember Regency, water sources.* ***Methods:*** *This research is an analytical observational study with a cross-sectional design. Data was obtained from water physical quality inspection and STH contamination in the water laboratory. The 30 samples were taken purposively.* ***Results and Discussion:*** *The results of the data analysis of the association between water temperature and STH contamination showed a p-value of 0.014, the association between watercolor with STH contamination showed a value of 0.566, and the association between odor and TDS of water with STH contamination was not analysed. Statistics analysis results showed a significant association between the quality of water physics and STH contamination in the water sources in Sumbersari District, Jember Regency, with a score of 0.022.* ***Conclusion:*** *The physical quality of water has a positive correlation with STH contamination in water sources in Sumbersari District, Jember Regency.*

INTRODUCTION

Soil-Transmitted Helminth (STH) infection is an infection caused by intestinal nematode worms that can be transmitted through soil media and is one of the most common infections worldwide. In 2020, according to the World Health Organization (WHO), 24% of the world population, i.e., more than 1.5 billion people, were infected with STH. This infection spreads in areas with tropical and subtropical climates, one of which is in Indonesia (1). The prevalence of STH infection in Indonesia ranges from 2.5-62%, most of which are due to poverty and poor sanitation (2). There are several factors influencing the high prevalence of STH infections in Indonesia, namely: Indonesia's humid tropical climate, population density, low socioeconomic conditions, and lack of clean and healthy living habits (3). Soil-Transmitted Helminths (STH) are transmitted through helminth eggs from the feces of an infected person. One of the most common forms of transmission route is through consuming contaminated water as water is the basic need of human. Improperly processed food and drink containing contaminated water can cause STH infections in humans who ingest them.

The major cause of water contamination by soil-transmitted helminths (STH) is the contamination of the soil surrounding the water source with feces from people with STH infection. The United Nations International Children's Emergency Fund (UNICEF) stated in its campaign that nearly 70% of the 20,000 household drinking water in Indonesia had been contaminated with fecal waste (4). Previous research in Sariwangi Village, Parongpong District, Bandung Regency, found that there was a contamination of worm eggs up to 119.44

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eggs/L water (5). Research conducted in Bandung in 2021 showed the existance of Ascaris spp. eggs on all samples of wastewater and sludge from the Bandung Bojongsoang Wastewater Treatment Plant (6). A study in the City of Kediri in 2020, which examined water pollution and rice fields on the transmission of STH to farmers, found 12 STH contaminated water from 18 samples taken (7). These studies show that water contamination by STH is still common and transmittable to humans.

Household water sources are water used to meet the community's daily needs, which can come from rivers, boreholes, dug wells, springs, and water from the Regional Drinking Water Company (PDAM) (8). Water worthiness can be measured by testing water quality using physical parameters. The increasing value of physical parameters can indicate a decrease in water quality. For example, the changing of water color to brown as a physical parameter indicates the decreasing physical quality of the water, which can be caused by external contaminants. Water polluted by bacteria can also cause water to have an unpleasant odor. Water with a particular taste can indicate that it has been contaminated by *E.coli* bacteria and heavy metals (9).

Jember Regency is a district in the eastern region of Java Island where the community has many variations of water sources used for their daily needs. The 2020 East Java health profile shows that Jember Regency is in the fourth lowest rank in the achievement of families with access to proper sanitation facilities (healthy latrines) and the 6th lowest in the achievement of qualified drinking water facilities (10). Sumbersari District has a percentage of the population with sustainable access to the safe drinking water of only 16.36% (11).

Previous research conducted in 2017 in Bogor shows that the water source of Situ Lebak Wangi still meets water quality standards based on physical and chemical quality tests. However, the presence of Coliform bacteria was found in biological tests (12). The physical quality of water and its effect on intestinal parasite contamination, especially STH is still an underresearched area. This study aims to determine the association between physical water quality and STH contamination in Sumbersari District, Jember Regency water sources.

METHODS

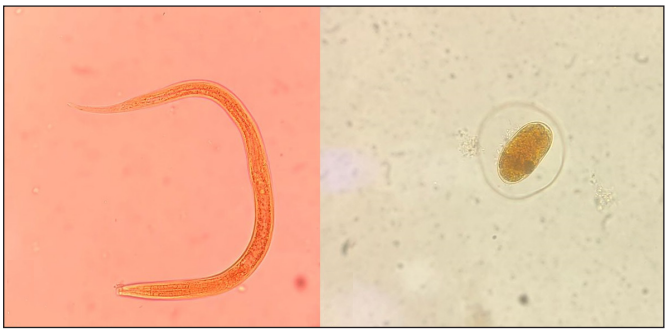
This research was an analytical observational study with a cross-sectional design. The population in this study was water from household water sources in Sumbersari district, Jember Regency. In this study, a purposive sampling method was used, with a sample size which included 30 samples. This study used primary data in the form of physical examination results of water quality and the presence of Soil-Transmitted Helminths (STH) eggs and larvae in household water sources in Sumbersari District, Jember Regency. Physical quality inspection of water was based on the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning environmental health quality standards and water health requirements for sanitary hygiene, swimming pools, solus per aqua, and public baths (13). Measurement of the physical quality of water included four components of color, odor, temperature, and dissolved solids. Examination of the color and smell of water was carried out using the senses of sight and smell, namely by seeing the color and smelling the water (8). Temperature checks were carried out using a thermometer to determine the water temperature from household water sources (14). Examination of dissolved solids in water was carried out by using a TDS meter (15). The physical water quality assessment was carried out based on the conclusions of 4 parameters, including temperature, color, odor, and TDS. It was said to meet the physical quality of water if all parameters, including temperature, color, odor, and TDS met the standard. In contrast, if one or more parameters did not meet the standard, the sample was considered not to meet good physical water quality. Research conducted in Minahasa Regency in 2018 examined water quality, with physical parameters consisted only of TDS values and turbidity (16). Meanwhile, research in East Kutai Regency in 2016 only used color, taste, and smell as parameters of the physical quality of water (17). Examination of Soil-Transmitted Helminths (STH) contamination in water was carried out by the method of floatation and sedimentation. Data analysis was performed using IBM SPSS Statistics 24 with the Phi Correlation test to determine the relationship and correlation value between variables.

RESULTS

This study utilized 30 samples of water sources taken purposively. The results of the examination of Soil-Transmitted Helminths (STH) contamination in water samples are as presented in Table 1. It shows that of the 30 samples taken, four positive hookworm samples were obtained, consisting of 3 Hookworm larvae and 1 Hookworm egg with a percentage of 13%. The results of microscopic examination of STH contamination are shown in Figure 1.

Table 1. Distribution of STH Contamination in Water Samples

Contamination Type	Amount	Percentage
Ascaris lumbricoides	0	0%
Tricuris trichiura	0	0%
Hookworm	4	13%
Not contaminated	26	87%
Total	30	100%



(a) *(b)*

Figure 1. Examination Results of STH Contamination in Water Samples Hookworm Rhabditiform Larvae *(a)* Hookworm Eggs *(b)*

The physical quality of water in this study consisted of temperature, odor, color, and Total Dissolved Solids (TDS). The results in this study were grouped into those meeting the requirements based on quality standards and those that did not. Temperature and TDS were measured using a thermometer and TDS meter. Observations of smell and color were carried out organoleptically with the help of two observers' senses of sight and smell. As many as 13 of the total 30 samples did not meet the standard temperature. 28 samples were clear in the color indicator, and the remaining 2 were colored. This study's odor assessment and TDS indicated that all samples met the quality standards. Each sample in this study was then analyzed regarding its physical quality, whether it met the requirement or not, based on the measurements of each indicator. Based on the analysis, it can be concluded that 16 water samples met the criteria of physical quality of water, and the remaining 14 did not meet the criteria. The bivariate analysis results between physical water quality and STH contamination in water are shown in Table 2 using Phi Correlation analysis.

Table 2. Bivariate Analysis Between Quality Water Physique and STH Contamination

Water Quality Indicator	STH Contamination						p-value	r
	Negative	%	Positive	%	Total	%		
Temperature								
Meet the criteria	17	57%	0	0%	17	57%		
Does not meet the criteria	9	30%	4	13%	13	43%	0.014	0.449
Total	26	87%	4	13%	30	100%		
Odor								
Meet the criteria	26	87%	4	13%	30	100%		
Does not meet the criteria	0	0%	0	0%	0	0%	-	-
Total	26	87%	4	13%	30	100%		
Color								
Meet the criteria	24	80%	4	13%	28	93%		
Does not meet the criteria	2	7%	0	0%	2	7%	0.566	-0.105
Total	26	87%	4	13%	30	100%		
Total Dissolved Solids								
Meet the criteria	26	87%	4	13%	30	100%		
Does not meet the criteria	0	0%	0	0%	0	0%	-	-
Total	26	87%	4	13%	30	100%		
Physical Quality of Water								
Meet the criteria	16	53%	0	0%	16	53%		
Does not meet the criteria	10	33%	4	13%	14	47%	0.022	0.419
Total	26	87%	4	13%	30	100%		

The results of data analysis of water temperature and Soil-Transmitted Helminths (STH) contamination in water with the Phi Correlation test showed a significant value of 0.014 ($p<0.05$). This shows a statistically significant association between water temperature and STH contamination in water. Water temperature shows a moderately positive correlation with STH contamination in water with a value of 0.449 on the strength of the correlation. The association between water odor and STH contamination in water was unable to be analyzed using the Phi Correlation test because the water smell in this study was constant. Phi correlation analysis shows that watercolor significantly correlated to STH contamination in water with a significance value of 0.566 ($p>0.05$). It shows that, statistically, watercolor was not significantly associated to STH contamination in water. Table 2 explains that the total of 30 samples used in this study met the standard criteria in the TDS indicator.

The data analysis using the Phi Correlation test showed that the data could not be analyzed because all TDS results were constant. Phi correlation test results showed a significance value of 0.022 ($p<0.05$) for the physical quality of water and STH contamination in water. This means that there was a statistically significant association between the physical quality of water and STH contamination in water. The physical quality of water with STH contamination in water had a moderately positive correlation with a value of 0.419.

DISCUSSION

Water quality is measured based on parameters and specific methods following applicable laws and regulations. Water quality standards for sanitation hygiene purposes consist of several parameters, namely: physical, chemical, and biological parameters. Mandatory parameters for physical parameters that must be checked for sanitary hygiene purposes include color, temperature, odor, Total Dissolved Solids (TDS), turbidity, and taste. Water turbidity is an essential parameter in determining the physical quality of water. One indication of pollution in water sources is the occurrence of turbidity in the water (18). Turbidity has a positive correlation with the TDS value in water; the higher the turbidity of the water, the higher the TDS value in the water, and vice versa (16, 19). Total Dissolved Solids (TDS) or total dissolved solids are solids dissolved in water in the form of organic and inorganic substances, namely all metals, minerals, salts, and ions dissolved in water (15). Inorganic materials (such as metal ions, iron, and manganese) and organics can cause coloration in water. The color of water can be determined more specifically on the True Color Unit (TCU) scale as measured by a colorimeter; however, the color test can only be done through observation, which was the limitation of these referred studies (20−21). The measurement of color, smell, and taste can directly use organoleptic assistance carried out by at least 2 observers to see color, smell, and taste of water samples, then provide an assessment of color (colored or not), odor (smelled or not), and taste (with taste or not) (21−22). Temperature measurement is mandatory in water quality assessment. Water temperature measurements were carried out directly in the field with the help of a thermometer.

Soil-Transmitted Helminths (STH) contamination in water can be interpreted as pollution or as the presence of STH in the water. STH contamination in water is caused by various factors, such as the sanitaion of the water facility and the environment. Inadequate water and sanitation conditions will trigger higher worm species transmitted through polluted soil and poor personal hygiene (23). Poor wastewater tunnel facilities can post the risk of contaminating water sources and the surrounding environment. Ideally, wastewater tunnel needs to befully enclosed, and waste water needs to be fully treated before being disposed of. An open wastewater tunnel posts a risk of transmitting diseases caused by waste disposal. Waste from the tunnel can also be inundated with water during the rainy season, especially if it does not have a secured drainage system. With regards to this, some factors can prevent the transmission of STH infection, namely building the floor of the house higher than the yard surface and wearing footwear (24). The use of wastewater for irrigation will post an increased health risk. Worm infection can be transmitted through the type of irrigation that can cause contact (5). Using latrines that contain feces directly in contact with the ground or a septic tank post a risk to leakage and result in water contamination in dug wells through soil seepage (25). In addition, the unavailability of toilets and the habit to defecate in the river will affect the spread of worm eggs growth due to fecal contamination in the running water used in the daily life (26).

Association among Temperature, Odor, Color, and TDS of Water with STH Contamination

The results of the data analysis on the association between water temperature and Total Dissolved Solids (STH) contamination through the Phi Correlation test showed a significance value of 0.014 ($p<0.05$). It means that there was a statistically significant association between water temperature and STH contamination in water, with a correlation value of 0.449, which is a moderate positive correlation. Temperature is the degree to which a substance is hot or cold. In this study, the temperature values were grouped between meeting and not meeting the requirements based on the quality standards, namely: the temperature was considered to meet the requirements if it was ±3°C from the air temperature. The water temperature in this study was related to the presence of STH contamination in the water. The literature states that temperature only affects the activity of microorganisms and the solubility of chemicals in drinking water, and it does not directly affect health (27). According to research conducted in Makassar in 2016, the water temperature was below the air temperature instead of above the air temperature (28). Another study conducted in Situbondo in 2021 examined the factors influencing STH cysts contamination in dug healthy water. No STH was found in all samples with an average water temperature of 31.6°C. This can happen because an increase in temperature can cause egg to die at a certain degree (25). All samples contaminated with STH in this study had an average temperature of 31.67°C, which was included in the category of above air

temperature (>3°C). This is in line with the literature which states that *N.americanus* eggs can develop optimally at the temperature of 28-32°C and *A.duodenale* at 23-25°C (25). *A. lumbricoides* eggs will develop optimally at 25°-30°C, and *T.trichiura* eggs will mature at an optimal temperature of 30°C (16).

The results of the odor examination in this study were constant. Therefore, data analysis could not be carried out. In this study, all samples did not have an odor. A study in Palembang stated that odor could indirectly be a clue in determining water quality (21). The smell of water can occur when water is polluted by bacteria (9). Bacteria require iron or sulfurin their life cycle and emit gases that cause odor, namely hydrogen and sulfide (21). Bacteria can contaminate water in various ways, from waste disposal in rivers to defecation. If people infected with STH do defecation activities in this river, they will release the eggs and cause water contamination. A study in Pekanbaru explain that a significant association between latrine use habits and STH infection. In this study, many people still defecate in rivers or ditches that flow into rivers, which post a great potential risk for worm infection (29). In this current study, most people already have closed waste disposal. This can minimize seepage and the levels of bacteria in the water. Examination of river water samples from Sumbersari District showed that the river water had an odor and was contaminated with STH. The smell of the sample can be caused by bacterial contamination. It can be caused by people's habit to defecate in the river and that the perpetrator was infected with STH. Hence, STH eggs contaminated the river water.

The results of the analysis of watercolor with STH contamination through the Phi Correlation test show a significance value of 0.566 (p>0.05), which means that there was no statistically significant association between watercolor and STH contamination in water. In this study, only 2 (7%) samples were colored, and none of the two colored samples was contaminated with STH. Meanwhile, among the 28 (93%) colorless samples, there were 4 contaminated with STH. The color of the water must be distinguished between the transparent color due to suspended substances and the original color due to dissolved materials (17). Water can become cloudy and have color if it contains a lot of suspended particles of material. Materials causing color and turbidity are mud, clay, well-dispersed organic matter, extracts of organic compounds, and plants (28). Color in water can also result from contact between decaying organisms and water (30). In this study, the color in the water sample may be caused by plants such as moss in the well, clay and mud at the bottom of the well, and dirt in the water pipe. This study also showed that the color did not appear in the water contaminated with STH. This could be due to the high density of STH eggs or larvae in the water that they did not result in significant color changes and were not detected by the sense of sight.

The association between water TDS and STH contamination cannot be statistically analyzed because the TDS value produced in this study was constant. All samples met the quality standard for the TDS value, namely 999 mg/l. A literature study written in 2018 in South Africa and Senegal stated that STH eggs are particles that can form suspended solids in water (31). Meanwhile, another study conducted in 2013 explained a negative relationship between live worm eggs and total worm solids because an increase in total solids effectively reduced the concentration of worm eggs in feces (32). Research in Rural Ghana in 2014 explained that there was no significant relationship between water quality in the form of TDS and conductivity with diarrhea and parasitic infections. In this study, river water consumed by the community had a TDS value of 35mg/l, but 43% of the people were infected with worms (33). This can occur due to many factors that can cause STH infection.

Association between Water Physical Quality and STH Contamination

According to WHO, one of the transmission routes of STH is the ingestion of eggs from contaminated water (1). Good water quality is vital to stop the transmission of STH infection (23). Poor sanitation and drinking water quality are significantly associated with the risk of infection transmission (34). Research conducted in Guatemala explains that there is a statistically significant relationship between water quality and the presence of STH. In the study in Guatemala, 6.6% of samples were STH-positive (34). The water polluting parasites could be used as an early warning indicator of water quality degradation (35).

This research is in line with previous research. The results obtained in this study are presented in Table 2. The Phi Correlation test displays a significance value of 0.022 (p<0.05), meaning a statistically significant association exists between physical water quality and STH contamination in water. In this study, 53% of the samples met the criteria for good physical quality water, and 47% did not meet the criteria. This study is not in line with the research conducted in 2020, which stated that the availability of clean water measured using physical water quality parameters did not significantly affect intestinal worms' presence (36). Other factors can affect the occurrence of helminth infections such as good personal hygiene and the physical quality of well water, namely: the distance and number of pollutant sources around water sources, the direction of groundwater flow,

climate, soil type, construction of dug wells, and depth, groundwater surface.

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CONCLUSION

Based on the results and discussion of the research on the association between physical quality of water and contamination of Soil-Transmitted Helminths (STH) in water sources in Sumbersari District, Jember Regency, it can be concluded that the physical quality of water has a positive correlation with STH contamination in water sources in Sumbersari District, Jember Regency. There is also a positive correlation between water temperature and STH contamination in water sources. Watercolor has no association with STH contamination in water sources. Meanwhile, the association between odor and Total Dissolved Solids (TDS) of water with STH contamination in water sources in Sumbersari District, Jember Regency, was unable to be analyzed because odor and TDS in this study were constant. The most prevalent type of STH that contaminated water sources in this study was Hookworm, with a prevalence of 13%.

Based on the results of this study, it is suggested that further studies add other indicators to the water quality test, including taste and turbidity tests on physical, chemical, and biological quality tests. This study's odor and color tests need to be improved due to the risk for bias ofbecause organoleptic method. The results of this study show that the physical quality of water was related to the presence of STH contamination in the water. This study can help inform the community to be more cautious if there are changes in their household water quality, such as changes in smell, temperature, color, taste, and turbidity of the water.

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