JPII 8 (3) (2019) 328-338

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

PHYSICAL WASTEWATER FROM ASSALAYA SUGARCANE FACTORY: REALITY AND PERCEPTION

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DOI: 10.15294/jpii.v8i3.20290

Accepted: May 30th, 2019. Approved: September 28th, 2019. Published: September 30th, 2019

ABSTRACT

Wastewater physical examination is acknowledged as one of the fundamental parameters for identifying water quality and alleviating the environmental ramifications caused by waste. This study aims to analyze water quality and determine possible consequences on the White Nile River by performing waste analysis generated by Assalaya factory located in Assalaya province, White Nile state, Republic of Sudan. Samples collected included Total Dissolved Solids (TDS), Turbidity, Total Suspended Solids (TSS), Odor, Color, temperature, and conductivity. This study employed questionnaires to recognize community perceptions. Data analysis revealed that the river had been significantly contaminated. The highest recorded concentrations for TDS, Turbidity, TSS, Odor, and Color were 1186 ppm, 28500 NTU, 2333 Mg/l, unacceptable,840 TCU,1830 µS/cm and 37.5 ºC, respectively. These results are not recommended by the international standard for water quality (WHO) approved range. Hence, to avoid the aftermath of the factory wastewater, this study recommends some actions to promote biological treatments. The stakeholders should inevitably follow the environmental water policy and establish the medication near the river. The government should independently administrate this manner. On the other hand, the factory should obey global transformation towards their production schemes such as Eco-friendly, Green-economy, and Sustainability concept in line with social, economic, and ecology sectors.

Keywords: community perception, factory wastewater, physical factories

INTRODUCTION

Pointless wastewater is usually discharged to neighboring areas via river streams (Van et al., 2013); these undesirable compounds releases encumber to the environment together with several extraordinary amounts of physiochemical pollutants (Rattan et al., 2015). Many scholars have emphasized that wastewaters of sugar factory hold a massive impact on water quality (Fachinelli & Pereira, 2015). The sugar mill is one of the biggest agro-based factories; they absorbed around 1500–2000 liters of freshwater and generated nearly 1000 liter of wastewater in a single production (Sahu & Chaudhari, 2015). There are several kinds of wastewater treatment process encompasses electrocoagulation, chemical coagulation (Sahu et al., 2017); and bio-coagulation (Kasmi, 2018).

However, treatment relies on the type of existing contaminants in wastewater (Bhatnagar, 2010). These treatment processes comprise a series operation unit that can be practical in different amalgamation based on the principal situations of the waste concentration (Kushwaha, 2013). Wastewater can result in numerous kinds of diseases; also, could damage lifestyle, human health, and environmental (González-Mariño et al., 2016). Company activities extensively utilize water (Hess et al., 2016). Water is an essential component to support the sustainability of organisms, human beings, food production, and economic development.

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Water should have decent management (Sharifinia et al., 2016; Halder & Islam, 2015). The present situation of water quality management is far from satisfying due to the implication of anthropogenic and population growth (Saha et al., 2016). Now, there are many cities worldwide suffering from an acute shortage of water; yet, almost 40% of the world's food supply on the manufacturing processes requires water (Halder& Islam, 2015).

Excellent quality of drinking water is a critical demand and is an essential element for all living recipients (Ali et al., 2014; Ewaid & Abed, 2017). Today, the health problem of water pollution is increasing, and many of the unaddressed brutal health consequences both nationally and internationally levels pose significant policy challenges (Wang & Yang, 2016). Also, the flowing pollutants into water body spread organic pollution, toxic pollution, eutrophication, along with severe ecological destruction (Wang & Yang, 2016). Wastewater habitually contains pesticides, herbicides, and pathogens from the input materials during the production process. Therefore, it has ample powers to degrade water characteristic in the river (Bechara et al., 2016).

The river is a significant source of freshwater and considered as the primary supply for providing the essence of life; when the loss of water comes up, life would not be maintained (El-Shakour & Mostafa, 2012). The freshwater exists only 3% of the cumulative water on earth; hence, it is necessary to preserve that tiny portion for rational use. Unfortunately, this low quantity of freshwater faces enormous stress because of the rapid progress in the world's population, urbanization, consumption by industries, agriculture, and daily conveniences.

According to the United Nations (UN) report, the world population is horrendously increasing while the freshwater availability is declining, and many countries in Africa, the Middle East, and South Asia suffer water scarcity. In developing countries, the water sources encounter various obstacles due to lack of proper management, financial constraints, and inefficient regulations (Azizullah et al., 2011). Therefore, the process of reusing wastewater has been increasingly emphasized in many countries to resolve water deficiency (Wang &Yang, 2016).

There are immense sources of the pollutants which have a significant role in altering the physical water characteristics. Besides, the sugar factory has been associated with the roots of negative externalities. The primary purpose of this paper is to disclose the physical constituents of the White Nile affected by Assalaya sugar factory wastewater. The physical test results validated by the community perception in the study area. Drinking water has several physical characteristics; nonetheless, the study is restricted to the particular characteristics of sugarcane production.

The analyzed physical parameters in this study comprise of TDS at 22.6 Cº, Turbidity, Odor, Color, and TSS. Each parameter contains 20 samples accompanied by a geographical coordinate system to locate the stations. The study compares the results with the WHO physical variables, a reliable reference to understand the water quality status in Sudan.

METHODS

Time and Research Location

This wastewater characteristic study used both primary and secondary data. The primary data were obtained by conducting laboratory analysis to identify the physical characteristics. Questionnaires, physical inspections, and interviews were carried out to verify the community perception of the water quality. Finally, the secondary data used in this paper are the WHO range and the data of the population.

The research was undertaken from January– March 2019. Geographically, the study area is located in Assalaya Province, White Nile State, 280 km South of Khartoum (the Capital of Sudan) and 5 km North of Rabak Town (the capital of White Nile State). Astronomically, the Longitude 32:3:55 West - 33:00:00 East and the Latitude 14:00:00 North - 14:00:00 South, as shown in Figure 1.

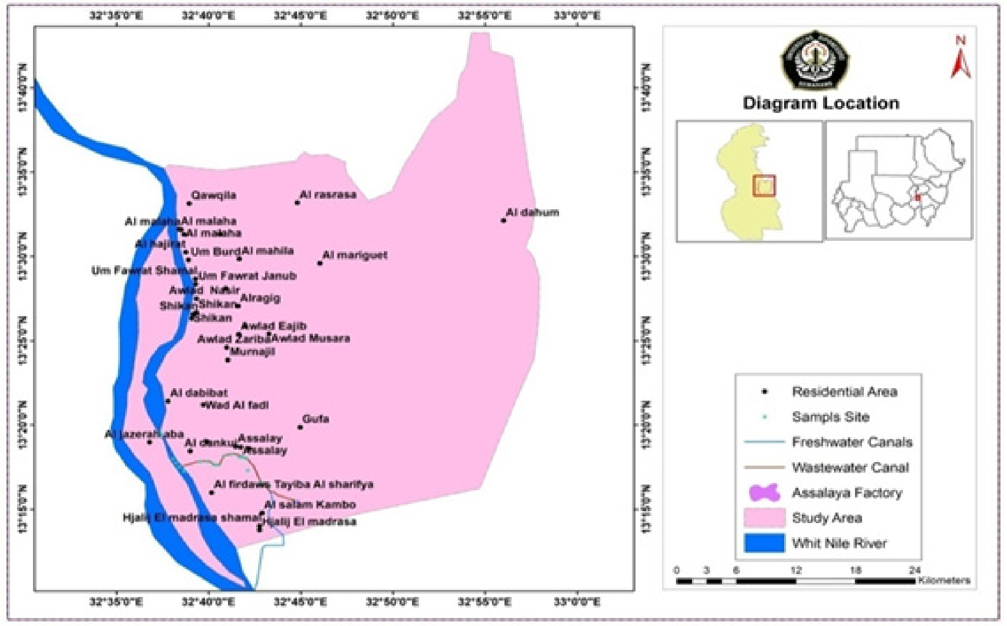

Figure 1. The Study Area

Data Collection on Wastewater Samples

The study utilized two types of data. First, the primary data consists of 20 samples of wastewater as pointed in Figure 2, coordinate of stations and observation, satellite data, and questionnaires. Second, the secondary data, which is the standard of water in Sudan recommended by WHO and number of population.

Data Analysis of Physical Parameters

The study used particular types of instrument: the conductivity meter for TDS; photometer to measure Turbidity, Color, and Odor; and filtration system with gravimetric variable scale to measure the TSS. The study used Microsoft Excel and SPSS to process the graph.

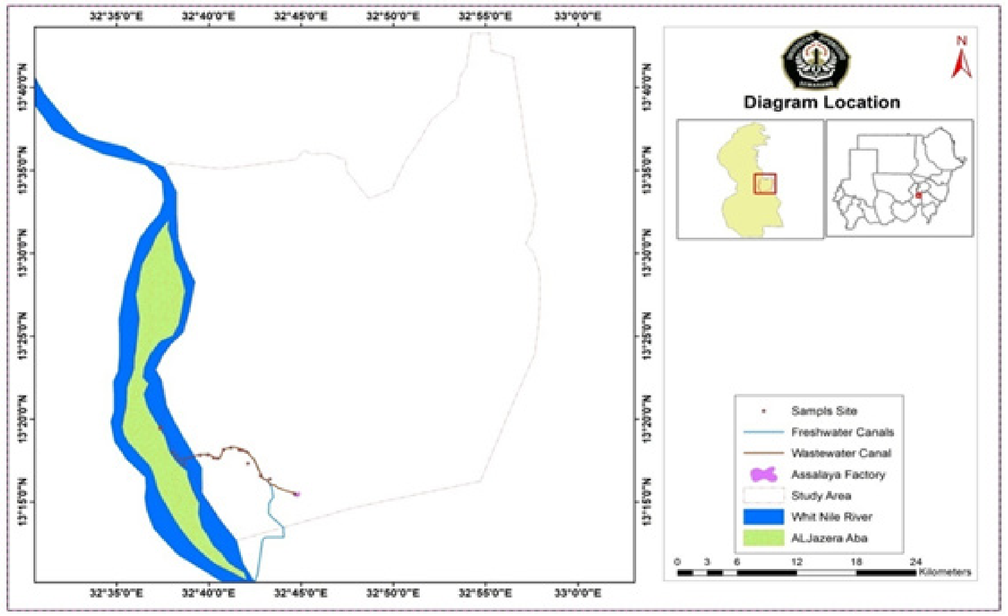

Figure 2. Wastewater Sampling Location

RESULTS AND DISCUSSION

By conducting physical tests on 20 samples, the study discovered that the factory waste had influenced the majority of samples. These results agreed with the WHO threshold range, as shown in Table 1.

Table 1. The Physical Variables of the Wastewater

Station Samples	X	Y	TDS	Turbidity	TSS	Odor	Color	EC	Tem
Station 1	32.66577	13.29801	1186	28500	2333	N. A	840	1594	37.5
Station 2	32.65937	13.29774	1052	700	540	N. A	260	1830	35.2
Station 3	32.67493	13.29436	965	195	800	N. A	75	1500	30,8
Station 4	32.67119	13.29508	117.6	12	488	A	25	150	25.4
Station 5	32.67973	13.30269	593	295	1500	N. A	110	820	24.2
Station 6	32.7007	13.30044	157.4	880	644	N.A	60	190	22.8
Station 7	32.69744	13.30215	156.6	230	6360	N.A	65	189	22
Station 8	32.6974	13.30222	160.6	1150	176	N.A	45	193	22
Station 9	32.7007	13.30045	168.8	310	3944	A	40	203	21.5
Station 10	32.7007	13.30044	175.1	205	1432	N.A	35	210	21
Station 11	32.70069	13.30044	191.5	4400	8248	N.A	20	230	21
Station 12	32.70069	13.30044	178.8	2100	724	N.A	25	211	20.8
Station 13	32.70071	13.30047	177.2	1200	628	N.A	25	211	20
Station 14	32.70073	13.30052	174.5	2600	448	N.A	30	210	20.6
Station 15	32.70073	13.30054	171.7	18	52	N.A	25	210	17.6
Station 16	32.7007	13.30055	209	1200	612	N.A	35	320	17
Station 17	32.70052	13.30067	559	4000	3220	N.A	55	802	15
Station 18	32.68704	13.30497	541	1950	1284	N.A	50	790	12
Station 19	32.65502	13.2975	229	46	284	A	30	360	12
Station 20	32.65572	13.29562	220	320	696	N.A	60	340	12
WHO			1000 mg/L	5 NTU	50mg/L	Acceptable	15 TCU	400 µS/ cm	25 ºC

X: latitude Y: Longitude

Total Dissolved Solid (TDS) at 22.6 Cº

TDS is originated from natural sources of anthropogenic activities like factories waste (El et al., 2012). In this case, the study assigned to designate roots of sugar factory wastewater through the laboratory analysis with temperature 23.40 Cº and 40% relative humidity. The study found that there are irregularities in the results of the entire values except in two stations (first and second stations), amounted to 1186 mg/Land 1052 gm/L respectively, as indicated in Figure 3. In addition, the minimum disclosure threshold is 1000 gm/L.

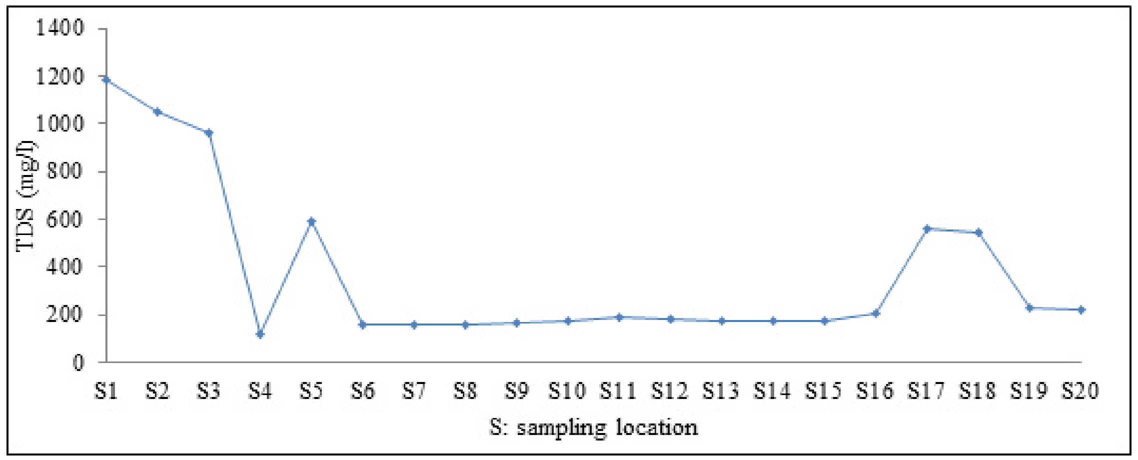

Figure 3. The TDS Values of the Study Area

The first and second stations possessed the highest concentration of TDS; both of them are close to the source of wastewater. The station one is situated near the factory outlet and had a substantial amount of suspended solid materials from factory chemical inputs amounted to 1186 mg/L. The permissible limit by WHO is 1000 mg/L, meaning that the amount at station one was higher than the standard range. In contrast, the fourth station held 117.6 mg/Las the sample was taken from the canal that provides freshwater used as a drinking source for many residents.

From station 4-15, the TDS concentrations were noticeably decreasing due to the canal's slope. These findings agree with a previous study conducted by Shahata & Thabet Mohamed (2015), in New Asyut, Egypt. They discovered the value of TDS was 183.5 mg/l, lower than the maximum threshold recommended by the Egyptian Law 48/1982 (500 mg/l), and also less than the value suggested by USEPA (500mg/l).

Turbidity

Turbidity is an indicator to measure cloudiness or clarity of the water (Kale, 2016). This study found a different concentration of Turbidity from several stations. The first station presented the highest amount of Turbidity at 28500 FTU and is close to the factory outlet. The lowest concentration was situated at station four, amounted to 12 FTU, as shown in Figure 4.

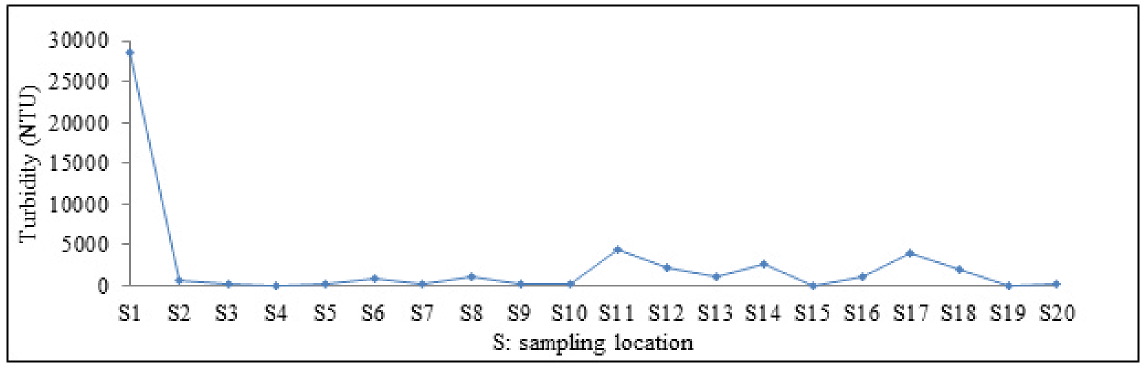

Figure 4. The Turbidity Values in the Study Area

The turbidity varies in the study area, and some values were higher than the WHO's. The first station showed the highest amount, 28500 FTU, and is incomparable with the standard range due to its outstanding value. A large amount of waste from the factory causes a high concentration of Turbidity. Turbidity value increases and fluctuates with various percentages. Stations 19 and 20 are located within the White Nile River, in the Al Jazeera Aba area. Although the Turbidity is considerably high, the residents still use the water as a source of drinking. The findings of this study are comparable to previous studies conducted in Cairo, Egypt; the Turbidity level of a river can determine the pollution intensity, with Turbidity values ranging from 8 - 26.5 to 21 - 62.5 NTU (El et al., 2012). High Turbidity of water may cause some diseases. Kale (2016), proved that alarming rates in temperature, pH, Turbidity, dissolved oxygen, water, and quality parameters could support pathogens growth and cause waterborne diseases. Luckily, a traditional water treatment process, if operated correctly, could effectively eliminate Turbidity.

Total Suspended Solid (TSS)

TSS is the tool to measure the suspended particulate matter in the water and is the vital parameter to understanding the physics of water quality contaminated by waste (Wu et al., 2019), and (Sikorska et al., 2015). TSS has a significant correlation with the Turbidity; an increase in the Turbidity characterizes a high suspended solids.

Through data analysis, the study found that a substantial amount of suspended solids is linear with Turbidity, and the concentration varies from outlet to downstream. Moreover, this study analyzed the sample using a filtration system with a gravimetric variable scale and mg/L unit variable, as presented in Figure 5.

Based on Figure 5, this study revealed that the water contained large amounts of suspended solids. The first station with TSS 2333 mg/L is close to the factory outlet area. This high concentration is triggered by a waste source around the first station. The second station is located in the wastewater pond, with a TSS value of 540 mg/L. The amount of the second station was lower than the first one. In general, the values are out a range of the standard recommended by the WHO as similar with Turbidity. As the increase in turbidity is followed by the high concentration of TSS, both TSS and Turbidity are out of the standard.

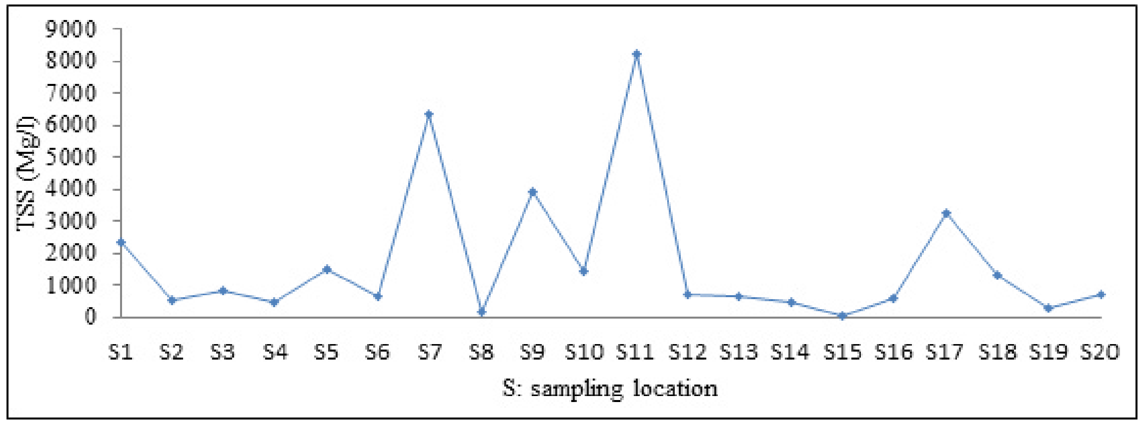

Figure 5. The TSS Values of the Study Area.

The variation happens due to the wastewater accumulation that has been deposited in ponds for a long time. On the other hand, some stations have relatively high accumulation because they contain newer amounts of sugar cane residue. Furthermore, the location and topography of water flow have a significant role in influencing the TSS; however, TSS should not have extreme values. This is supported by previous research conducted in the US confirmed that an excessive-level of TSS could reduce and deplete the amount of oxygen in drinking water (Verma et al., 2013).

Odor

Odor can be released toward residential neighborhoods by wind due to the lack of a treatment system of wastewater (TSWW) (Zhou et al., 2016). The Odor usually comes from different sources. Typically, the source of the Odor is the factory waste, which has many types of chemical substances used as input materials for producing sugar. Through the analysis by photometer, the study revealed that the entire samples are unacceptable but three samples: station four (4), ten (10), and nineteen (19) as seen in Table 1. In this case, the specification and permissible limit of Odor represented are acceptable, referring to the WHO.

The fourth site sample was taken from the canal containing freshwater, while the tenth site was located between the outlet and downstream area. Most of the residents around the study area suffer from odor emissions, and the survey proved that the emissions are the result of pollutants. The odor is distasteful to human beings and disturbs normal life-breathing. The previous study by Estrada et al. (2015) on integral approaches to wastewater treatment for preventing odor, revealed that odor's emission is inherently related to wastewater management. Another study conducted in Australia on a survey of the odor impact on communities ratified that most odor observations were predominantly attributed to the wastewater treatment plants (Hayes et al., 2017).

Odors develop a significant environmental issue. Some studies demonstrate that exposure to odors may provoke various effects on human health, ranging from emotional stresses such as anxiety, headaches, depression, and other physical symptoms. Odor leads to nuisance problems when industrial activities are running around residential areas (Capelli et al., 2011).

Color

Color is an expression of the dissolved coloring mixtures, both organic and inorganic materials in the water column. Color sometimes would not cause a problem unless there is a change in its composition. Color is pigment or substance that dissolves in water (Pavithra et al., 2019).

Through laboratory analysis, this research unveiled different color values. The highest concentration was found at the station close to the factory site; then the value dropped to the mouth of the sewage. After that, they increased again in upstream and downstream of the river, as shown in Figure 6. The standard of WHO highlights that the permissible limit is 15 TCU. When the samples were checked and analyzed using photometer as shown in Figure 5, the highest color value,840 mg l-1 Pt, was recorded at the first station. Then, the second and fifth station had 260 mg l-1 Pt and 110 mg l-1 Pt, respectively. The lowest value was found at station 11 with 20mg l-1 Pt. Overall; the general appearance indicated that there is relative variation in the results. Concerning the watercolor, the study found that some samples were out of the permissible limit. The first station held the highest number with 840 mg/l Pt and is situated at the source of the factory outlet. The second site is 265 mg/l Pt and considered abnormal because the sample was taken from the wastewater pond that has been deposited for a long time. Based on the observation, it has a stinky odor with foam floating on the pond surface.

The previous study by Mohsin & Sahib (2013) confirmed that 86% of residents have clear water, and a few residents have diluted and faint water. Also, the water quality is fair in this area because of its vicinity to the river. However, this study confirms that most of the residents have no clean water, as shown in the test results related to water odor; seventeen stations are acceptable, and three stations are unacceptable. The water quality is unsuitable in terms of color despite being near the river. Sugarcane wastewater contains a massive amount of contamination that may change watercolor (Sahu, 2016).

Previous research confirmed that sugar factory wastewater could generate waste and spread odors to neighboring areas up to several meters. The results of this research prove that the wastewater before treatment was dark yellow, then changed to light yellow after being treated. Wastewater without proper treatment will cause serious environmental problems. Therefore, it is necessary to treat wastewater appropriately before being discharged into the environment (Sahu & Chaudhari, 2015).

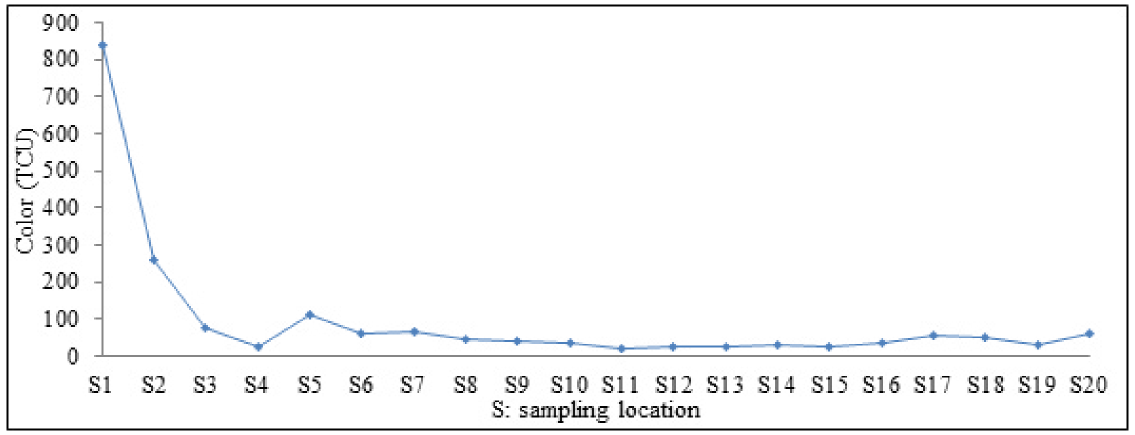

Figure 6. The Color Values of the Study Area

Temperature

The study found that most of the values are within the standard recommended by the WHO. Nevertheless, the first three locations recorded the highest values, which were 37.5, 35.2, and 30.8ºC, respectively. The temperature in the water is not always constant (Salim et al., 2014). There was a little variation in the results. In general, the water temperature in the study area ranged from 37.5 and 12°C, which refers to the polluted as pointed in Figure 7.

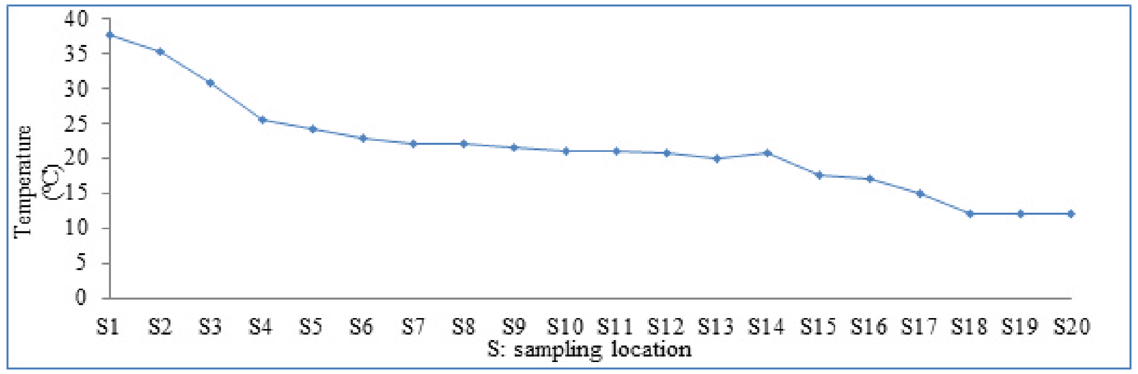

Figure 7. Water Temperature of the Study Area

The figure notes that the first and second location recorded the highest values as the first location is factory outlet and the second is the factory pond that has been made use to keep the wastewater before discharging into White Nile River. The variation in temperature depends on many factors parts of them are; the times of sampling and sunshine hours (El Shakour & Mostafa, 2012).

Electroconductivity (EC)

Electroconductivity has a strong relationship with solid dissolution because the solutions of inorganic acids and salts are reasonably respectable conductors (Gorde & Jadhav, 2013). Based on that concept, this study found different types of conductivity concentration ranging between 1830 – 210 μS/cm, as indicated in Figure 8.

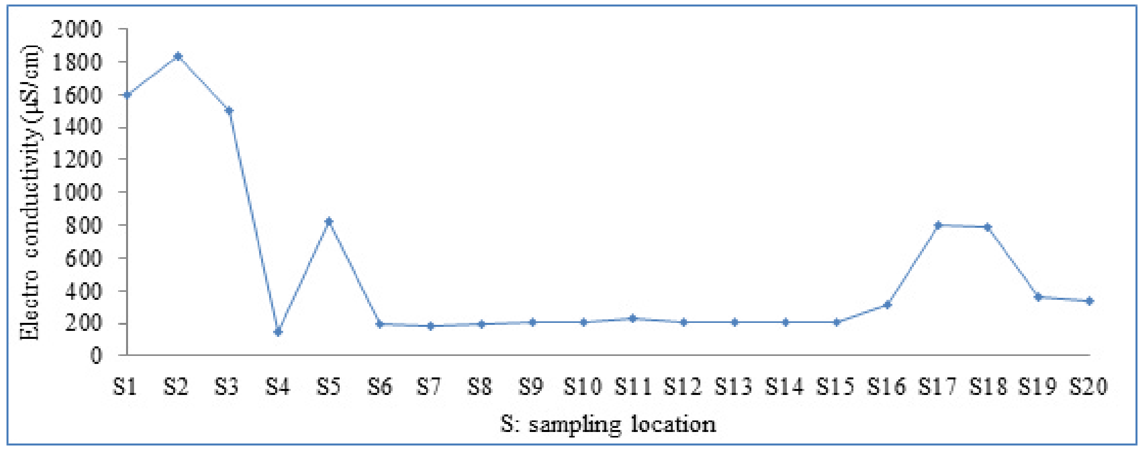

Figure 8. The Electro conductivity of the Study Area

The figure informs that the first three locations recorded the highest values respectively 1594, 1830 and 1500 mho/cm as they are nearby the wastewater source. EC measures the ability of water to carry electric current, and it has a strong relation with solid dissolution in water, habitually mineral salts (El Shakour & Mostafa, 2012). These high values pointed out that the water is receiving large amounts of the contamination, specially Assalaya factory pollutants. Respondents inhabiting Assalaya and Aljazeera Aba were chosen as research samples based on household dimension. According to the Central Bureau of Statistics, the number of household members in the determined area is 2816 people. Therefore, 10% of households were chosen to represent the entire study community. The total questionnaires for each region were selected based on the samples. They were selected proportionally based on household data using a purposive sampling technique, as shown in Table 2.

$$\frac{\sum \text{of households in respective village} \times 282/2816}{\left(\sum \text{households} \times \left(\frac{10}{100}\right)\right)}$$

Table 2. The Total Number of Households, the Samples Size Selection & the Techniques of Questionnaires

No	Households Name	Total of Households	The Samples Size Selection	The Techniques of Questionnaires Division
1	Alhajalij Almadrasat Janob	212	21	10
2	Alhajalij Almadrasat Shimal	194	19	10
3	Alsalam Alkambu	989	99	10
4	Alfirdaws Tayibah Alsharifya	204	21	10
5	Aldankuj	140	14	10
6	Hajar Assalaya Alum	93	9	10
7	Hajar Assalaya Alsharifia	145	15	10
8	Hajar Assalaya Shrq	437	44	10
9	Hajar Assalaya Gharb	153	15	10
10	Aljezeara Aba	249	25	10
	Total of Households	2816	282	

Source: The Study Analysis Based on the Central Bureau of Statistics

Based on community perception, the study area has several types of drinking water sources. According to the survey and questionnaire, the majority of people have used public waterways as the primary source of drinking water, as shown in Figure 9. The waterways were grouped into two types. The first type is the river flow that comes before the factory. Community members who live in this location are not affected because they use uncontaminated freshwater. The second type is the river flow that has been blended with wastewater from factory effluents, and some villages use it as drinking sources.

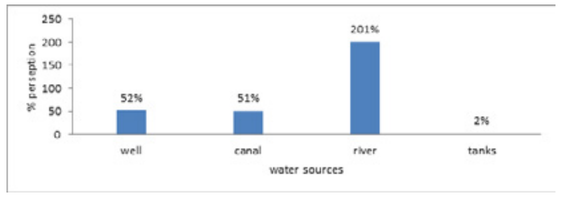

Figure 9. Water Sources in the Study Area

Through questionnaires and physical investigation, the researchers revealed that the communities in the study area have perceptions concerning water quality. The respondents stated that the source of public drinking water is close to the waste streams. The canal's water before the factory was deemed clean and could be consumed in two villages, Alhajalij Almadrasat Janob, and Alhajalij Almadrasat Shimal; these villages are not affected by the waste. On the other hand, eight villages are affected by wastewater as they used water that mixed with waste disposal.

The Community Perception of Water Quality

After comparing the analyzed wastewater with the water used by the communities, 214 respondents said that the water had an unusual taste, while 86 respondents accepted it as freshwater. The strange taste is expressed in many water variables, as shown in Figure 8. Through questionnaires and field surveys, 22.35% of the respondents stated that the water has a metallic taste, 24.62% of the respondents responded that the water has a salty taste, 31.44% of the respondents answered that the water is stinging, and 21.59% of the respondents said that the water has molasses and murky taste.

Concerning the water treatment system, some respondents used a filtering system. However, financial factors and economic constraints force them to use ineffective treatments. Therefore, they do not have enough money to meet the demand to get clean water. In general, the research area has several types of treatment systems, such as filtration treatment systems owned by 10.39% of the respondents, traditional treatment owned by 38.96% of the respondents, and defecation systems owned by 50.65% of the respondents. Most respondents face challenges on several types of pollutants.

Therefore, the community must use filtration treatments to reduce the impact of hazards. Also, according to the community, there are various types of pollutants found in canal water. They are wastewater, which was answered by 44.33% of the respondents; algae, which was answered by 27.66% of the respondents answered; and pesticides, which was answered by 28.01% of the respondents.

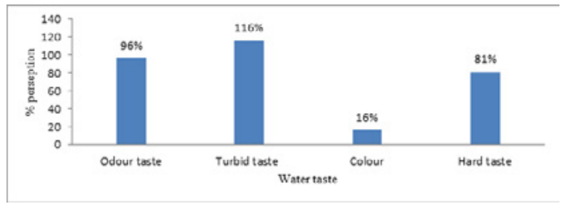

Figure 10. Water Taste in the Study Area

The water body in the study area is physically unacceptable due to the high turbidity and strong odor. There were 37.5% of the respondents said that the turbidity is high, 31% said the odor was unacceptable, and 5% confirmed about the watercolor problem. From this point of view, the study had similarities in ideas between public perception and laboratory analysis. Laboratory physical test results declare that water has a high amount of turbidity, an unacceptable odor, and disparities in watercolor.

According to the assessment results, the majority of water status exceeds the recommended value by WHO; hence, this study strengthens the perception of respondents living in the affected areas. On the other hand, about 21% of people who are not residing in the affected area admitted that water has a natural taste, little molasses, and low turbidity. Overall, the community perceptions indicated that chemicals in water have a significant role in changing water quality. Based on the annual community income survey, 154 respondents make less than 1000 SDG. Therefore, it is tough for them to own sophisticated water filtration instruments. Concerning water pollutants, 58.9% of community members considered factory wastewater is the main factor of externalities, and 65.6% of respondents believed that water from the river is unhealthy. The fact that factory wastewater is mixed with fresh water for many years can be seen from the change in its physiological characteristics. The changes in water compounds cause many diseases that are transmitted through dirty water, and this is in line with the patients claim recorded in the Assalaya hospital report.

CONCLUSION

There are variations in the TDS amount. Most of the values are below the WHO standard except for in two stations, the first and the second stations which amounted to 1186 mg/L and 1052 mg/L respectively. Concerning turbidity, the concentration varied from one station to another. Stations with high TDS values also held substantial turbidity. The value of TSS was linear with turbidity concentration, and the amount varied from downstream outlets. For water odor, most stations exceeded the accepted level, but in three stations, 4th, 10th, and 19th. Similar to odor, the color values also differed. The highest Color concentration was found at the outlet next to the factory. Regarding the water temperature, most of the values remained to meet the standard, although the area around the factory has the highest temperature. The value of EC was linear with TDS concentration. According to the community's perception, there are several types of water sources, and most people have used polluted waterways as a source of drinking water. A total of 214 respondents stated that the water they used had an unusual taste, which reflected by the metallic taste, murky, and colored; while 86 respondents accepted it as freshwater since they were not residing in the affected location.

The community has used several types of treatment systems; the common one is the refinement or defecation treatment system. Unfortunately, due to financial constraints, most of the citizens could not afford proper equipment for delivering clean water treatment.

ACKNOWLEDGMENTS

First and foremost, the author would like to express sincere gratitude to the family for raising him from the cradle to this stage of maturity. Secondly, many thanks and appreciation are addressed to supervisors: Prof. Purwanto and Dr. Henna RyaSunoko for the guidance in completing this dissertation. Enormous gratitude to Sudan's Higher Education and Omdurman Islamic University for supporting this project; also, to the fellows, Prof. Saleh Hadab Al Rasul, Dr. Omar Adam, Dr. Elyas Mansour, Dr. Ali Muddather, Mr. Ali Ahmed Smail, Mr. Muhammad Hamid Hassan, Mr. Ahmed Hamid, and Niyomukiza John Bosco for the entire outstanding scholarly assistance. Thanks for every comments, suggestions, and contribution that bring this research to the stage of completion. The last but not least, thanks very much to Lecturers of the Environmental Science Doctoral Program, Graduate School, Universitas Diponegoro, for the support and cooperation that make all of this come to happen.

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