

## Assessment of Wastewater Quality of Paharang Drain and its Impact on the Ground Water Quality of Adjacent Areas

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**Abstract:** This study was conducted to assess the effect of wastewater quality of Paharang drain Faisalabad on ground water quality of adjacent areas. Ground water samples and drain water samples were collected and analyzed by using standard methods. Parameters of wastewater samples were compared with Pakistan National Environmental Quality Standards (NEQS). Results indicated that physico-chemical parameters including pH, total dissolved solids (TDS), chloride, fluoride and total hardness were found exceeding the permissible limits in wastewater samples. Similarly, few physicochemical parameters in groundwater were found within the permissible limit while electrical conductivity (EC), TDS, chlorides (Cl), fluoride (F), and total hardness in most of samples were found above the Pak EPA and WHO standard limits. Heavy metals like nickel (Ni), chromium (Cr), iron (Fe), lead (Pb), and arsenic (As) were found within the prescribed concentrations in drain and ground water samples. Statistical analysis showed significant effect of some drain wastewater parameters like conductivity, TDS, salt, temperature, and Cl on the corresponding ground water quality. A strong positive correlation between pH, EC, TDS, Salt, and Cl in drain wastewater and strong positive correlation between EC, TDS and Salt in ground water samples was observed. For improving the ground water quality in the adjacent areas textile wastewater treatment all factories is required, and a combined effluent treatment plant (CETP) at the Paharang drain is also recommended.

**Keywords:** Ground water, heavy metals, Paharang drain, physico-chemical parameters, water quality.

### Introduction

The textile industry is one of the leading manufacturing industries in Pakistan. It is the second largest private employment sector in Pakistan that supports the largest employment for educated and uneducated, skilled, and unskilled labor (Farooqui and Ahmed, 2013). Apart from seasonal and recurrent instabilities, textiles products have an average share of about 57-60 percent in nationwide exports. The textile industry of Pakistan consists of ginning, spinning, printing, processing, dyeing, hosiery, and garments. Some fully unified composite units blend all the processes and production under one roof. These sectors are generally situated in Karachi, Lahore, Faisalabad, and Hyderabad. Textiles are being produced in large-scale manufacturing in organized and unorganized small and medium units (Hashmi et al., 2011). Faisalabad is the third largest city of Pakistan, with a population of around 6 millions. The sewerage system of the city is divided into eastern and western zones. The wastewater from western zone flows into the Paharang drain and ultimately into the Chenab river (Sial et al., 2006). The Paharang drain was excavated in 1973 to carry excess water from the waterlogged areas of Faisalabad with a length of about 84 km. Municipal and industrial effluents are actively received in the first 33 km of the drain. In Faisalabad, about 270 full scale textile units are working at present. Untreated effluents from several units are

discharged in the Paharang drain (Umm-e-Habiba et al., 2013).

The textile manufacturing process is environmentally hazardous due to its high-water consumption and variety or complexity of chemicals employed (Lopez et al., 2006; Arslan-Alaton and Alaton, 2007; Blanco et al., 2012; Khan and Khan, 2010). Variation in the cloth quality, color and treatment process results in significant deviation in daily flow rates and pollutant concentrations in textile wastewater (Bidhendi et al., 2007). Textile wastewater is one of the major contaminating sources in Pakistan (Sial et al., 2006). Among various pollutants found in the water, color is a critical factor that originates from partially/ completely untreated effluents from textile industries (Akan et al., 2012). Textile effluents contain significant amounts of suspended solids, additives, detergents, surfactants, carcinogenic amines, formaldehyde, heavy metals, and dyes. Fluctuating pH, high temperature, chemical oxygen demand (COD), and complex coloration are the foremost textile effluent characters. It causes severe environmental deterioration to the receiving water bodies (Nachiyar et al., 2012, Saeed and Hashmi, 2014). Also, heavy metals in textile wastewater like cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), nickel (Ni), and zinc (Zn), are directly taken up by the marine and fresh water biota or may cause contamination in the ground water (Akan et al., 2012, Sharma et al., 2008). Similarly, if the same

drain water is used for the direct irrigation of crops, it may affect soil fertility, crop yield, and quality. It is dangerous for consumers to utilize those crops (Hashmi et al., 2011). Around 30-50 % of inhabitants on both sides of the Paharang drain consume groundwater without any treatment, whereas the quality of that ground water is unfit for human consumption (Mahmood and Maqbool, 2006). Ideally, the textile wastewater should be treated at the industrial level before discharging it to the drain. Moreover, installing a combined effluent treatment plant (CETP) operated by the city government could be a solution to avoid receiving water body contamination.

Various biological and physico-chemical techniques are available for such combined domestic and textile wastewaters as conventional activated sludge (CAS), sequencing batch reactor (SBR), coagulation and flocculation, sand filtration, and activated carbon adsorption. As a standalone technique, SBR was found to be very effective on Paharang drain wastewater because it combines both aerobic and anaerobic biological treatment in a single tank. This combination is excellent for the degradation of textile dyes and takes up fewer footprints than standalone aerobic or anaerobic biological treatment techniques (Nawaz and Khan, 2013). However, the Pakistan National Environmental Quality Standards (NEQS) for safe effluent discharge are hard to meet with standalone SBR; hence, some post-treatment or tertiary treatments may be added. In another study on Paharang drain wastewater, it was revealed that CAS followed by sand filtration and activated carbon adsorption proved to be very useful and resulted in 81% COD and 94% color removal (Nawaz and Ahsan, 2014).

In the current study, we have measured the Paharang drain wastewater quality and assessed its impact on the ground water quality of the adjacent areas. The ground water quality was assessed to determine the contamination level and suitability for drinking purpose. The Sustainable Development Goal (SDG) 6 ascertains the accessibility and consumption of clean drinking water to all consumers. In this regard, few Physico-chemical parameters (pH, salts, EC, TDS, TSS, ORP, chlorides, total alkalinity, water hardness, flouride) and heavy metals (Cr, Ni, Fe, Pb) were targeted as critical and compared with the NEQS for effluent discharge and world health organization (WHO) standards for drinking water.

## Materials and Methods

Faisalabad industrial area with coordinates (31°28'36.9" N, 73°4'17.5" E) was selected for the present study. Paharang drain starts from Chak Jhumra, Faisalabad (Iqbal et al., 2016). During its length of roughly 84 km, it traverses through city industrial hubs and dense population clusters and agriculture farms before discharging into the river

Chenab. Therefore, the Paharang drain was selected for sampling (Fig. 1).

Ten (10) wastewater samples were collected from specific points of the drain over 4 km length. Fifteen groundwater samples were collected from the houses of surrounding residential areas. Sampling was done after 5-10 minutes pumping from the pumping wells of each house. The groundwater quality of selected areas was adverse under the Paharang drain influence. Consequently, residential areas of about 6.5 km<sup>2</sup> all over the drain were selected for groundwater sampling.

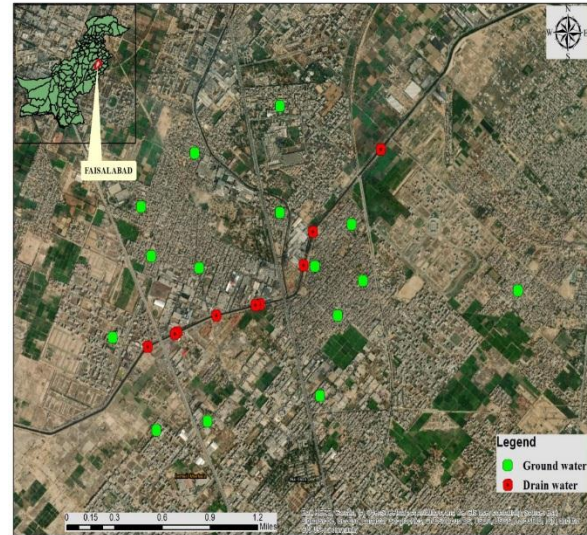


Fig. 1 Study area map.

Water samples were collected in 1000 ml plastic bottles previously cleaned with non-ionic detergents, washed with tap water, and finally rinsed with distilled water. The samples were labeled, placed in an icebox to retard any biodegradation, and carefully transported to the laboratory. The samples were stored in the refrigerator at about 4 °C before analysis. All parameters were measured according to standard methods (APHA, 2012). Arsenic was measured using an arsenic test kit (Econo Quick) and fluoride was measured using fluoride high range ISM mode. Heavy metals (arsenic, Fe, Pb, Cr, and Ni) concentrations were analyzed by using Thermo Scientific Atomic Absorption Spectrophotometer (Thermo scientific) Model No iCE-3000 Series.

Statistical analysis for T- test and Correlation analysis of drain as well as groundwater parameters using SPSS software was also done.

## Results and Discussion

### Physical and Chemical Characteristics

Collected samples were analyzed at the site and in the lab for the pH of wastewater and groundwater samples. The pH values of wastewater were found in the range between 7.2-9.16 (Table 1). Except for one value of 9.16, the rest were found within the Pak EPA

standards. This value is high because a textile drain outlet was near this sampling point, and due to the associated high pH of textile effluent, the drain pH

intestinal infections and gastrointestinal problems (Tariq et al., 2006).

Salt concentrations in wastewater samples were found

Table 1. Physico-chemical parameters of Paharang drain wastewater

Sample	pH	EC(mS /cm)	TDS (mg/L)	Salt (mg/L)	Temp (°C)	TSS (mg/L)	Chloride (Cl) (mg/L)	Fluoride (mg/L)	Total Hardness (mg/L)
DW-1	7.71	4.11	2910	2370	38.7	115	<b>1063</b>	<b>44</b>	630
DW-2	8.32	4.25	3010	2450	38.9	85	709	4	190
DW-3	7.20	4.35	3090	2520	39.1	40	709	<b>33</b>	440
DW-4	7.40	4.30	3050	2540	38.9	141	<b>1063</b>	<b>18</b>	270
DW-5	8.13	4.34	3080	2510	39	86	<b>1063</b>	<b>23</b>	170
DW-6	<b>9.16</b>	6.81	<b>4830</b>	<b>4050</b>	39	129	<b>2127</b>	<b>41</b>	280
DW-7	7.21	2.13	1500	1170	39.1	45	650	<b>31</b>	130
DW-8	8.15	4.40	3120	2550	39.2	155	<b>1400</b>	<b>55</b>	<b>1000</b>
DW-9	8.50	4.34	3080	2510	39.2	<b>1019</b>	<b>1418</b>	<b>24</b>	110
DW-10	8.31	4.25	3020	2470	39.2	80	<b>1480</b>	<b>47</b>	180
Pak EPA Standard	6.0-9.0	-	<3500	-	40	200	1000	10	-

Note: Bold indicates the higher values than Pak EPA Standard limits. (-) shows standards not available

increased. The pH of groundwater samples was found in the range of 7.13-7.93, with most falling within Pak EPA and WHO standard limits (Table 2). Wastewater pH controls many chemical reactions and aquatic life in wastewater receiving bodies like rivers and the ideal pH range is between 5.0 to 9.0 (Hanif et al., 2005).

EC values in wastewater samples were found in the range of 2.13-6.81 mS/cm as (Table 1). The results are in accordance with the other studies done on Paharang drain (Hashmi et al., 2011; Jamil et al., 2018). EC of groundwater samples was found in the range of 0.85-3.80 mS/cm above the WHO prescribed standards of 0.25 mS/cm (Table 2). It clearly shows that this water is not fit for drinking purposes. The decreased conductivity of the groundwater compared to the drain wastewater may be due to soil natural filtration. But it is essential to consider that high electrical conductivity may also affect soil productivity and interfere with its physical properties over prolonged exposure (Iriel et al., 2018; Pal et al., 2015).

TDS concentrations in wastewater were found in the range of 1500-4830 mg/L with only one value of sample 6 (4830 mg/L) above the prescribed limit (3500 mg/L) of Pak EPA standards (Table 1). The main reason for this sample to exceed was because it was near the industrial outlet. TDS concentrations in groundwater were found in the range of 608-2690 mg/L, with most of the values above Pak EPA and WHO standards of 1000 mg/L (Table 2). Water with high TDS concentration is not fit for drinking as well as irrigation purpose. High TDS water becomes hard and causes severe injuries to human health, including

in the range of 1170-4050 mg/L. Salt concentrations in groundwater were found in the range of 1020-2170 mg/L. The reduced salt concentration compared to drain wastewater may also be attributed to the underground strata's natural filtration (Rizwan-Ullah et al., 2009).

TSS concentrations in drain wastewater were found in the range of 40-1019 mg/L with only one value of sample 9 (1019 mg/L) exceeding the Pak EPA standard value of 200 mg/L (Table 1). TSS in groundwater values were found in the range of 3.90-23.3 mg/L. Although there are no prescribed limits for TSS in Pak EPA or WHO standards, it should ideally be zero as it gives a bad aesthetics to the drinking water.

The temperature of wastewater samples ranged from 38° to 39.2°C and was found within the prescribed limit of Pak EPA. This high temperature in the sampling month of November (cold climate month) shows that the drain is a main textile industry discharge source. Because textile wastewaters are generally associated with high temperatures above 40 °C. Temperature can change a drain wastewater quality by evaporating the water with increasing kinetic energy of molecules at high temperature and may pollute the surrounding air with a bad odor (Delpla et al., 2009).

Chloride (Cl<sup>-</sup>) concentrations in all wastewater samples were found in the range of 650-2127 mg/L. About 70% drain samples have Cl<sup>-</sup> concentration above the standard range of Pak EPA limit (1000 mg/L) as shown in Table 1. This high chloride concentration is associated with the high concentration of sodium chloride used in various unit processes in the textile industry. Cl<sup>-</sup> concentrations in all ground

water samples were found in the range of 212-1148 mg/L, while the allowable limit is only 250 mg/L as per both Pak EPA and WHO standards (Table 2). High

reduces the foam formation and results in the wasting of soaps and detergents.

Table 2. Physico-chemical parameters of ground water samples

Sr.#	pH	EC (mS/cm)	TDS (mg/L)	Salt mg/L	Temp. (°C)	TSS (mg/L)	Chloride (Cl) (mg/L)	Fluoride (mg/L)	Total Hardness (mg/L)
GW-1	7.54	<b>2.54</b>	<b>1800</b>	1410	20.6	16.2	<b>650</b>	<b>19</b>	<b>1280</b>
GW-2	7.75	<b>2.75</b>	<b>1940</b>	1530	20.4	6.7	<b>861</b>	<b>54</b>	210
GW-3	7.93	<b>1.98</b>	<b>1370</b>	1040	20.9	6.0	<b>329</b>	<b>63</b>	110
GW-4	7.63	<b>1.84</b>	<b>1310</b>	1020	20.9	7.3	<b>255</b>	<b>66</b>	<b>640</b>
GW-5	7.44	<b>2.66</b>	<b>1900</b>	1490	21.2	10.9	<b>574</b>	<b>30</b>	<b>860</b>
GW-6	7.6	<b>2.11</b>	<b>1500</b>	1190	21	5.9	<b>319</b>	<b>37</b>	390
GW-7	7.28	<b>2.20</b>	<b>1560</b>	1220	21	15.0	<b>425</b>	<b>39</b>	<b>1150</b>
GW-8	7.60	<b>1.86</b>	<b>1320</b>	1020	21.2	11.0	<b>269</b>	<b>45</b>	60
GW-9	7.33	<b>3.03</b>	<b>2150</b>	1710	21.6	6.0	<b>811</b>	<b>36</b>	<b>1080</b>
GW-10	7.64	<b>0.85</b>	608	456	21.4	23.3	212	<b>26</b>	180
GW-11	7.56	<b>3.61</b>	<b>2560</b>	2060	21.5	13.5	<b>776</b>	<b>14</b>	410
GW-12	7.55	<b>3.80</b>	<b>2690</b>	2170	21.7	14.0	<b>1148</b>	<b>56</b>	210
GW-13	7.18	<b>2.52</b>	<b>1790</b>	1410	21.6	3.90	<b>553</b>	<b>51</b>	<b>2580</b>
GW-14	7.13	<b>2.30</b>	<b>1630</b>	1280	21	6.70	<b>411</b>	<b>50</b>	<b>1840</b>
GW-15	7.15	<b>1.57</b>	<b>1120</b>	860	21.2	16.0	<b>379</b>	<b>45</b>	<b>1370</b>
Pak EPA Limits	6.5-8.5	-	<1000	-	-	-	250	1.5	<500
WHO Standards	6.5-8.5	0.25	<1000	-	-	-	250	1.5	200

Note: Bold indicates the higher values than Pak EPA Standard limits.

chloride concentration affects aquatic life (Smakhtin et al., 2004). High chloride in drinking water causes unpleasant taste and diseases such as gastrointestinal problems, diarrhea, and dehydration. Low concentrations of chloride and sodium chloride are less harmful (Zheng et al., 2013).

Fluoride concentrations in drain wastewater were found in the range of 4-55 mg/L while the prescribed limit is 10 mg/L. Fluoride concentrations in ground water were found in the range of 14-66 mg/L, while the allowable limit is only 1.5 mg/L (Table 2). The high concentration of fluoride is present in the soil, air and aquatic water bodies in the form of fluorite, cryolite, and fluorapatite. High concentration of fluoride has chronic effects on children and adults by the consumption of fluoride contaminated water. High fluoride concentration causes dental fluorosis in children and severely affected spinal problems and joints pain in adults (Chakraborty et al., 2009).

Total hardness of all drain water samples were found in the range of 110-1000 mg/L (Table 1). In groundwater it ranged between 60-2580 mg/L and were mostly found above the standard limits of Pak EPA and WHO standards. The higher hardness of groundwater compared to the drain wastewater shows that calcium and magnesium have been dissolved in the ground water over the years. Hard water is unfavorable because it

reduces the foam formation and results in the wasting of soaps and detergents. Heavy metal concentrations of Pb, Fe, Cr, and Ni in all wastewater and ground water samples were below the measuring range and were not detected. Pak EPA standard limits for lead, iron, chromium, and nickel are 0.5, 2.0, 0.5, and 1.0 mg/L. For heavy metals analysis, the AAS device had minimum detection limits (lead 0.2 mg/L, iron 2.0 mg/L, chromium 0.2 mg/L, and nickel 0.6 mg/L) in a flame method. The heavy metals like Pb, Fe, Cr and Ni in all groundwater samples were not detected. Arsenic concentrations in all wastewater samples were found in the range of 0.025-0.05 mg/L and within the Pak EPA standard limit. Arsenic concentrations in all groundwater were found in the range of 0.005-0.01 mg/L which is below the Pak EPA standard limit.

**Statistical Analysis**

The results of wastewater and groundwater samples were analyzed through the independent sample T-Test (Table 3). Results showed that mean values of EC (4.33, SD ±1.108), TDS (3069, SD ±788.6), Salt (2514, SD ±682.6), temperature (39.03, SD ±0.164) and chloride (1168.2, SD ±454.13) in wastewater is higher than the Mean values of ground water samples. It shows that these five parameters have a significant effect on the ground water parameters. While the pH, TSS, fluoride, and total hardness showed insignificant

Table 3. Independent T-Test of all physico-chemical parameters of drain wastewater and ground water samples

Sr. no.	Parameter	Sample Type	Sample no.	Range	Mean	Standard Deviation	Significance
1	pH	Wastewater	10	7.25 - 9.16	8.0150	± .610	P = 0.006
		Ground water	15	7.1- 7.9	7.4873	±.232	
2	EC	Wastewater	10	2.13-6.81	4.3280	± 1.1084	P = 0.00
		Ground water	15	2.1-1980	2.3747	± 0.7579	
3	TDS	Wastewater	10	1500 – 4830	3069	± 788.648	P = 0.00
		Ground water	15	608-2690	1683	± 536.685	
4	Salt	Wastewater	10	1.17- 4.05	2514	± 682.678	P = 0.00
		Ground water	15	1.02-230	1324.4	±443.694	
5	Temperature	Wastewater	10	38° - 39.2°	39.03	±.164	P = 0.00
		Ground water	15	20.4° - 21.7°	21.15	±.374	
6	Chloride	Wastewater	10	7.09 -21.27	1168.2	± 454.13	P = 0.00
		Ground water	15	21.27 -1148.58	531.47	± 270.657	
7	TSS	Wastewater	10	0.8 -1019	109.94	±.319.446	P = 0.237
		Ground water	15	3.9–23.3	10.82	± 5.420	
8	Fluoride	Wastewater	10	1.8 -5.5	32	± 15.297	P = 0.121
		Ground water	15	1.9 -14	42.07	± 15.360	
9	Total Hardness	Wastewater	10	10 -1000	340.00	±281.306	P = 0.085
		Ground water	15	60-2580	785.71	±740.693	

Results are expressed in mg/l, except for pH, EC in mS/cm and Temperature in ° C. Effect is Significant at the level  $P \leq 0.05$  (two tailed).

influences on ground water. The T-test showed  $p < 0.05$  for pH, EC, TDS, salt, temperature and chloride concentrations in the drain and groundwater samples.

Pearson correlation coefficients of parameters show the relationship between two or more variables that

assisted to analyze the primary responses of these parameters in wastewater and groundwater samples (Wu et al., 2014; Imtiazuddin et al., 2012). Pearson correlation differences of these parameters were analyzed by using SPSS (Statistical package for the

Table 4. Pearson correlation of physico-chemical parameters of wastewater samples.

Sr. no.	Parameters	pH	EC	TDS	Salt	Temp	Cl	TSS	F	TH
1	pH	1	.745	.745	.738	.162	.819	.312	.113	-.108
2	EC		1	1.00	1.00	-.086	.787	.010	.163	.114
3	TDS			1	1.00	-.083	.787	.011	.163	.114
4	Salt				1	-.089	.789	.004	.161	.109
5	Temperature					1	.223	.360	.293	-.053
6	Chloride						1	.198	.491	.100
7	TSS							1	-.183	-.279
8	Fluoride								1	.635
9	Total Hardness									1

Results are expressed in mg/l, except for pH, EC in mS/cm, and temperature in ° C. Correlation between two parameters may vary between -1 to +1.

Table 5. Pearson correlation of physico-chemical parameters of ground water samples.

Sr. no.	Parameters	pH	EC	TDS	Salt	Temp.	Cl	TSS	F	TH
1	PH	1	-.046	-.057	-.060	-.354	-.023	.004	.127	-.836
2	EC		1	1.00	.999	.272	-.591	-.271	-.119	.024
3	TDS			1	1.00	.279	-.454	-.266	-.128	.031
4	Salt				1	.291	-.350	-.256	-.135	.027
5	Temperature					1	.052	.132	-.157	.144
6	Cl						1	-.067	-.096	-.023
7	TSS							1	-.539	-.242
8	Fluoride								1	-.009
9	Total Hardness									1

Results are expressed in mg/l, except for pH, EC in mS/cm and Temperature in ° C. Correlation between two parameters may vary between -1 to

social sciences) software for window 10 and results are shown in Table 4 and 5.

The Pearson correlation for the wastewater parameters (Table 4) indicates that wastewater parameters showed a strong positive correlation with other parameters such as pH with EC, TDS, salt and Cl, TDS with EC, Salt, pH, and Cl. These results may be realistic because EC can be influenced by the dissolved salts present in the water path. These dissolved salts depend on the chlorides and other free ions present in water (Tariq et al., 2006). The existence of free ions affects the electrical conductivity of water (Priya and Arulraj, 2011). While the other parameters such as temperature, Cl, TSS, fluoride and total hardness were found in negative, weak, or no relationship.

The Pearson correlation for the ground water parameters indicated a strong positive correlation between EC with TDS and salt (Table 5). It also showed the moderate negative relationship of EC with Cl and a strong negative correlation between total hardness and pH. The negative strong correlation is indicated because total water hardness is composed of magnesium and calcium hardness (Priya and Arulraj, 2011). While the other parameters such as pH, EC, TDS, temperature, Cl, TSS, and fluoride showed no relationship with other parameters.

## Conclusion

Wastewater samples from Paharang drain showed TDS, salt, chloride, fluoride, pH, and total hardness in various samples above the permissible limits of Pak EPA. Hence the drain wastewater cannot be directly used for agricultural purpose or dumped into the Chenab river without prior treatment. Accordingly, the groundwater samples with high TDS concentrations, salt, total hardness, Cl and fluoride are not safe for drinking purpose. Though, heavy metals concentrations were found within the Pak EPA standards, groundwater needs treatment before use for potable purpose. Statistical analysis showed a significant effect of drain wastewater parameters like EC, TDS, salt, temperature, and Cl on the corresponding groundwater quality parameters. At the same time, the other parameters like pH, TSS, fluoride and total hardness showed insignificant influence on the groundwater quality. A strong positive correlation between (pH, EC, TDS, Salt, and Cl) in wastewater and a strong positive correlation between (EC, TDS, and salt) in groundwater was observed. It shows how varying one characteristic of the drain may affect the other characteristics and how seasonal variations can affect the drain wastewater quality and ultimately

groundwater quality in the underlying strata. To improve the groundwater quality, it is recommended to have treatment of textile wastewater at an industrial level in all industries contributing towards Paharang drain. Moreover, the installation of a combined effluent treatment plant on Paharang drain based on SBR or CAS technology with tertiary treatment is recommended. It will improve the quality of Paharang drain wastewater and ultimately the quality of groundwater.

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