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Effect of the Kossodo Industrial Wastewater Discharges on the Physico Chemical Quality of Massili River in BURKINA FASO

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Abstract

Ouagadougou, capital of Burkina Faso, includes within its industrial zone Kossodo Brewery, a Slaughter house, a Tannery and other small industrial units such as those of soaps. All these factories discharge their wastewater into the river Massili which is tributary of Nakambé, one of the major rivers of Burkina Faso. Previous studies have shown that Massili was polluted due to industrial and domestic activities and that this had an impact on the aquatic life of the streams (dead fish); water drilling for drinking water along the Massili were similarly polluted by heavy metals from waste of the industrial zone of Ouagadougou. In view of all these pollution problems posed by wastewater on streams, it is important today to know the current state of the physicochemical quality of the effluents from the industrial zone of Kossodo that flow in the basin of the Massili. This is the objective of this study. We therefore took samples from ten (10) different locations along the pipeline of the wastewater discharges into the Massili. The following parameters were analyzed: BOD_5, COD, nitrates, orthophosphates, electrical conductivity, dissolved oxygen, pH, temperature and SPM. The results of our analyses show that SPM, BOD_5, COD, dissolved oxygen and orthophosphates have values above the required standards, so the industrial waste pollute the Massili streams.

Keywords: Pollution, problems, industrial, domestic, activities, Nakambe.

Introduction

Burkina Faso is a Sahelian country situated in the heart of West Africa, covering an area of 273 187 km^2, with a population of 13.4 million and an average density of 48 inhabitants per km^2. Ouagadougou the capital city located in the province of Kadiogo, has an estimated population of 1,676,565 inhabitants[1]. The population growth, urban development and certain industries contribute to the emergence of problems of water pollution and public health[2]. The issue of preservation of water resources and their quality as well as the protection of wetlands cannot be overlooked[3,4]. The population explosion is always accompanied by a high need for water and huge discharges of liquid effluents[5]. The amount of domestic and industrial liquid waste in most cities in developing countries nowadays raises a serious problem of pollution of watercourses[6]. As such, the Massili tributary of Nakambé (ex. White Volta) is the main river that receives the majority of both domestic and industrial wastewater treated and untreated from Ouagadougou. Previous studies showed that the Massili was polluted due to industrial and domestic activities and this pollution had an impact on the aquatic life of streams (dead fish reported) as well as water boreholes drilled for water supply along the watercourse[7,8,9]. The water in Massili was polluted by heavy metals from waste of the industrial zone. In fact, most industries are poorly equipped for the treatment of effluents and for the physicochemical analysis of discharges into the natural environment. The impact of industrial development on water quality and soil is therefore a new threat to the environment and future water uses. In Ouagadougou, the industrial zone is located in Kossodo and includes, in addition to major industries such as the Brewery, Slaughterhouse and Tannery, small industrial units like those for making soaps. In view of all these pollution problems posed by the wastewater streams, it is important today to know the physicochemical state of the effluents from the industrial zone of Kossodo which flow into the basin of the Massili. This has led to the present study aimed at determining the current physicochemical quality of wastewater of the industrial zone of Kossodo flowing into the river Massili.

Material and Methods

Sampling: Ten (10) sampling points (PP) shown on the map in the figure-10 in annex were selected along the streams of the wastewater discharges into the Massili. These are: PP1: output of the tannery (Tan Aliz Company) wastewater; PP2: meeting point of the tannery wastewater with wastewater from other industrial units of Kossodo (except for the Brewery Brakina and the Slaughterhouse); PP3 and PP4: on the water pipe leading to the meeting point of the wastewater and the Massili; PP5: meeting point between industrial wastewater and Massili; PP6 and PP7: water channeled to market gardening; PP8, PP10 and PP9: water of the Massili from the National Park Bangr-Weogo. The samples are taken in polyethylene 1 liter bottles. The samples were stored in a cooler with ice and transported to the laboratory for analysis. Table-1 in annex gives the details on the sampling sites.

Methods of analysis of the different parameters: For this study, there was no in situ measurement. The following parameters were considered. The biochemical oxygen demand (BOD_5): BOD_5 values were obtained by the respirometric method with thermoregulatory equipment "Lovibond OxiDirect." The chemical oxygen demand (COD): it was determined by the traditional method in feroïne. Organic materials contained in the water are oxidized by an excess of potassium dichromate in an acidic medium and in the presence of mercury sulfate. The excess potassium dichromate was determined by titration with iron sulfate and ammonium sulfate[10]. Orthophosphates: the determination of orthophosphates was done by spectrometry with MULTI TESTS ORCHI-1. The blue ammonium paramolybdate with antimony and potassium tartrate in acid medium was used. Nitrates: spectrometric method with MULTI TESTS ORCHI-1 was used for the determination. Suspended Matter (SPM): SPM determination was made by filtration and drying in an oven at 105°C for 4 hours. The principle and method are described in the French standard NF 90-105.

The conductivity, dissolved oxygen, pH and temperature were determined using the HQ40d unit equipped with digital sensors IntelliCAL^{TM}.

Results and Discussion

The table-2 in annex presents the results of the different parameters analyzed and standards of wastewater discharges into surface waters[11].

We interpret below parameter by parameter, after plotting the data representing the changing values of these parameters depending on the location of sampling in figure-1 to figure-9.

The temperature: Figure-1 in annex shows the evolution of the temperature as a function of sampling sites. The measurements carried out in May between 9 am and 1 pm gave values between 29.5°C and 36°C. These results meet the standard temperature which is between 18 and 40°C[5]. However, the values are higher than those by other authors in previous work (between 27.50°C and 33.50°C during the period from July to August)[8]. This difference can be explained by the measurement period. The temperature is a parameter that influences other such as dissolved oxygen, pH and density of the water. This is an important ecological parameter because its elevation may cause the death of some aquatic species such as fish.

Table-1
GPS of collection sites and dates of sampling

Sampling site	GPS	Date of sampling
PP1	N 12°24'53.5" W001°28'35.7"	05/28/2012
PP2	N12°24'51.3" W001°28'38.1"	05/28/2012
PP3	N 12°24'50" W 001°28'37.5"	05/28/2012
PP4	N 12°24'37.6" W 001°28'28.5"	05/28/2012
PP5	N 12°24'33.8" W 001°28'26.1"	05/28/2012
PP6	N 12°24'36.8" W 001°28'24.6"	05/28/2012
PP7	N 12°24'35.7" W 001°28'22.3"	05/28/2012
PP8	N 12°24'39" W 001°28'18"	05/28/2012
PP9	N 12°24'31.2" W 001°28'31.9"	05/28/2012
PP10	N 12°24'31.2" W 001°28'31.3"	05/28/2012

Table-2
Results of analyses

	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	Standards
Temperature (°C)	29.8	30.2	30.8	32.2	32.6	33.5	34.1	36	35.5	34.7	18-40
pH	7.93	7.74	7.85	8.41	8.15	9.11	8.4	9	8.7	7.84	6.4-10.5
Conductivity (µS/cm)	8190	8860	8320	4900	5760	735	6190	737	728	420	-
Dissolved oxygen (mg/l)	0.53	0.53	1.05	0.78	0.91	11.2	0.49	7.9	8.39	5.92	-
Nitrates (mg/l)	0	0	0	0	1	0	0	0	0	0	50
Ortho-phosphates (mg/l)	5.5	6.8	6.4	4	4.5	0.1	4.3	0	0.1	0.4	5
COD (mg/l)	980	1660	-	1120	1070	90	980	-	-	30	150
BOD5 (mg/l)	225	806	298	573	454	93	436	195	190	199	40
SPM (mg/l)	450	420	1040	210	240	70	110	100	90	40	200

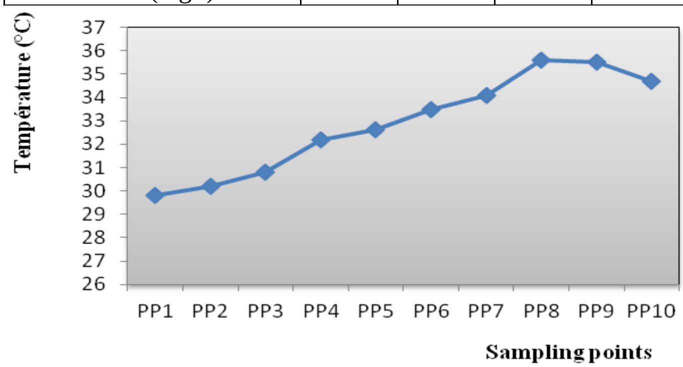


Figure-1
Evolution of temperature along the sampling points

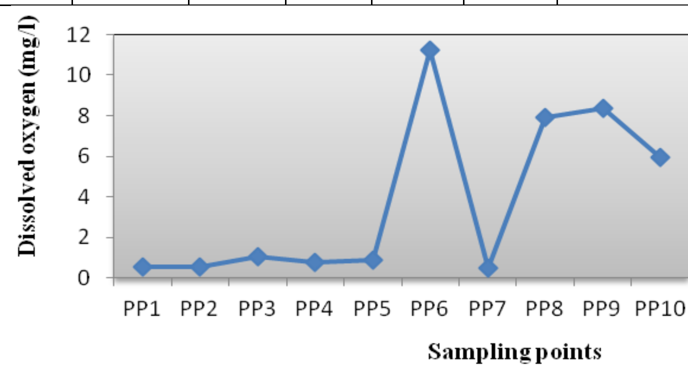
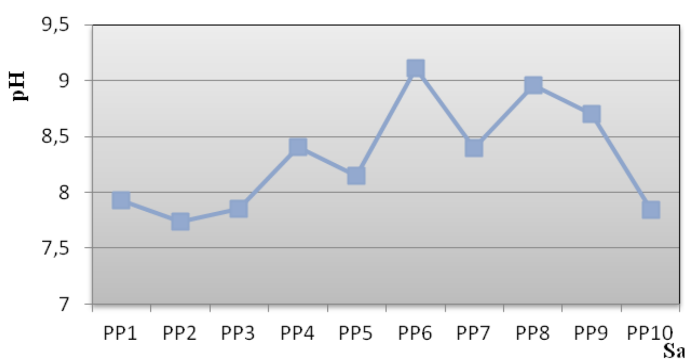


Figure-4
Evolution of the dissolved oxygen along the sampling points



Sampling points

Figure-2
pH changes along the sampling points

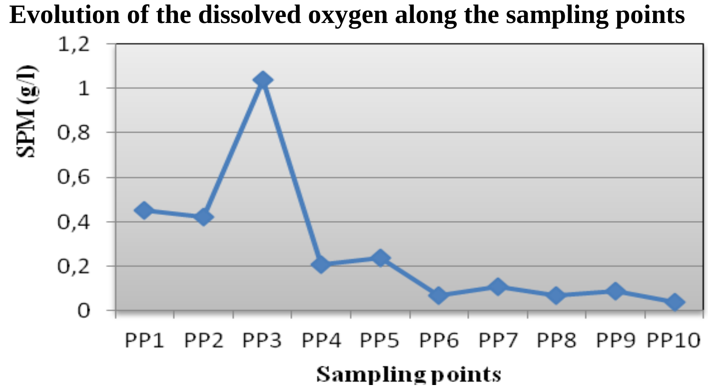


Figure-5
Evolution of the suspended matter (SPM) along the sampling points

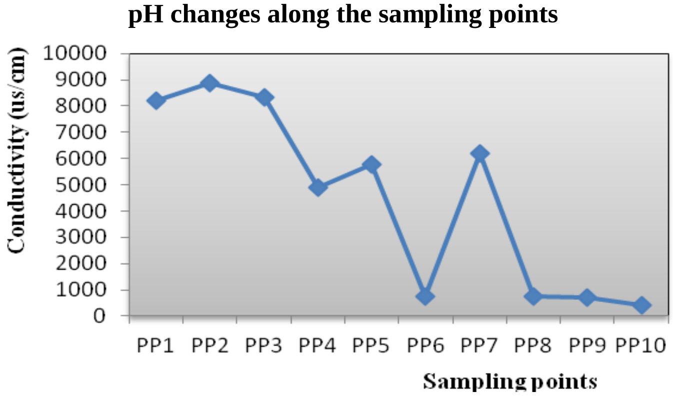


Figure-3
Evolution of the conductivity along the sampling points

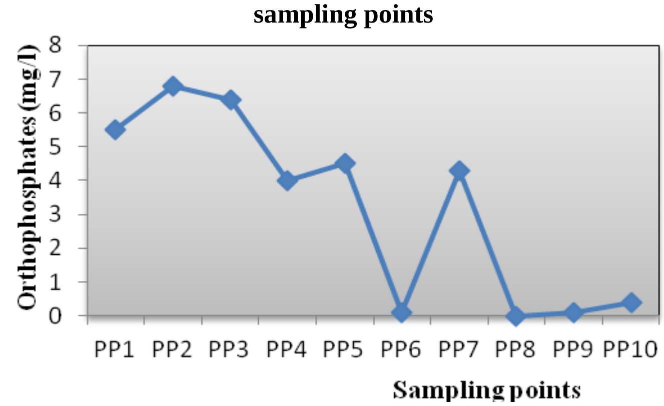


Figure-6
Evolution of the orthophosphates along the sampling points

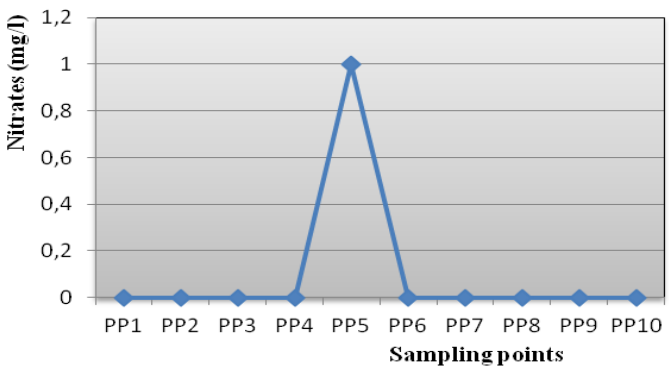


Figure-7
Evolution of the nitrates along the sampling points

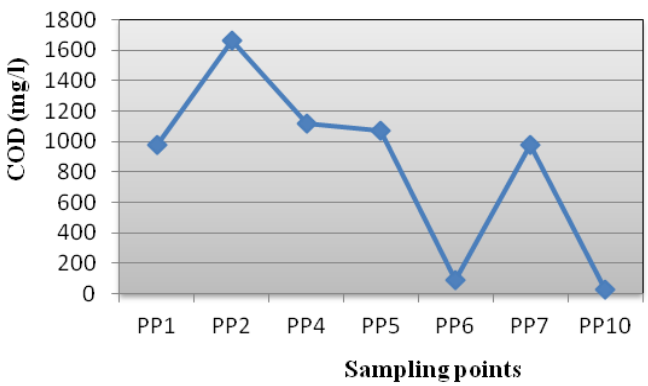


Figure- 8
Evolution of the COD along the sampling points

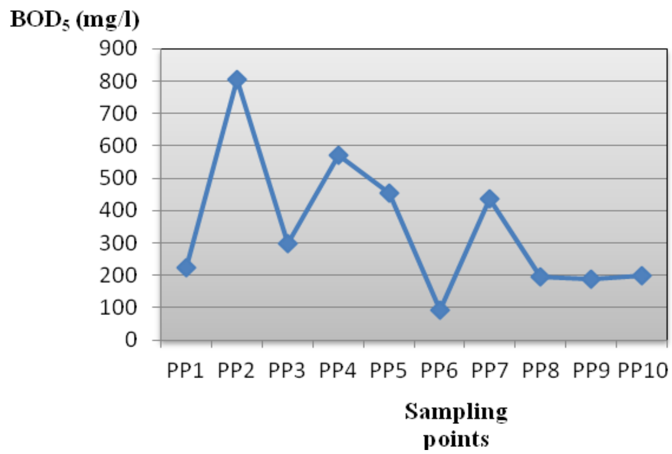


Figure-9
Evolution of the BOD_5 along the sampling points

Changes in pH: The pH of the different samples is between 7.74 and 9.11 in the figure-2 in annex. It meets the discharge standards of 6.4 to 10.5 in Burkina Faso[5]. All values are greater than 7, implying that all of the samples analyzed are basic. According to formerly authors, Massili pH was between 6.7 and 8.7 and complies with Burkina Faso standards[7,8,11]. Indeed, this basic form is due to effluents from products (KOH, NaOH) used in some industrial units such as soap manufacturing and also in tanneries. In addition, water from the National Park Bangr-Weogo (PP8, PP9 and PP10) which is downstream of the outfall of the effluent from the industrial zone in Kossodo is also basic.

Figure-10
Map of the zone of study

It therefore appears that the effluents of the industrial zone are not solely responsible for the alkalinity of the water in Massili. Since the pH influences the chemical reactivity of some substances and may have a direct impact on their toxicity, the alkalinity of the water may affect not only aquatic species but also surrounding populations.

Evolution of the conductivity: Conductivity is a measure of the ability of a substance to conduct an electric current; it is an indirect measurement of the content of ions in the water. The more water conducts electrical current, the higher the measured conductivity and this shows indirectly that the content of ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^-, Cl^-, SO_4^{2-}) in the water is high.

The results of our analyses in the figure-3 in annex show values between 420µS/cm and 8860 µS/cm. This conductivity is high for effluents from the industrial zone Kossodo (PP1, PP2, PP3 and PP4). The same observations are made at sampling points PP5 and PP7 which are respectively the meeting point between industrial wastewater and the Massili and a point downstream corresponding to water channeled for market gardening. However, the values of the conductivity of the water from Bangr-Weogo at PP8, PP9 and PP10 located upstream of the meeting point between the industrial wastewater and Massili are relatively low. One observes from figure 1 and 2 that the conductivity correlates well with the pH at these sites; the higher the pH, the lower the conductivity and this may indicate that most of these ions form precipitates in basic medium in the presence of OH^- and CO_3^{2-}. Although our studies did not aim the determination of chromium ions, previous works revealed relatively high content of chromium in Massili caused by the extensive use of its salts by the Tannery[2]. The high conductivity of the effluent from the industrial zone Kossodo is due to the use of chemicals that impact on the conductivity of Massili.

Evolution of dissolved oxygen: Dissolved oxygen is an important ecological parameter because its presence allows breathing of living organisms in water. Water is qualified polluted if it has a dissolved oxygen content of less than 3 mg/l[12]. The results of our analyses in the figure-4 in annex give values between 0.53 and 11.2 mg/l. It was found that the content is less than 1 mg/l, not only for the industrial effluents (PP1, PP2, PP4), but also for the meeting point between the industrial wastewater and Massili (PP5). However, for water from the National Park Bangr-Weogo, dissolved oxygen content is relatively high (> 5mg/l at PP8, PP9 and PP10). This shows that the effluent from the industrial zone is polluted and the pollution affects the water in Massili. Previous work also showed values well below the accepted standard (5 ppm instead of a minimum of 80 ppm)[11,13]. Work on Massili, done upstream and downstream of the dam of Loumbila showed that dissolved oxygen was higher upstream than downstream, but values did not meet the standard allowed[11,14]. These findings were explained by the fact that upstream, the gardeners were using motor pumps and sprinklers above the dam to collect water, which disturbed the water and facilitated its oxygenation, unlike downstream sites where water was calmer.

Suspended Matter (SPM): The figure 5 in annex shows the evolution of SPM with sampling points. The results of our analyses give values of SPM between 40 and 1040 mg/l. This allows us to see that the levels of SPM effluent from the industrial zone (PP1, PP2, PP3 and PP4) are higher than the standard set (200 mg/l)[11]. In effect, the level of SPM is below the standard for the water coming from the Park Bangr-Wéogo (PP8, PP9 and PP10). This high content of suspended industrial effluents higher than the accepted standard prevents the dissolution of oxygen as attested by the low dissolved oxygen concentration at these sites and affects the quality of water in Massili.

Content of orthophosphates: Orthophosphates PO_4^{3-} are contained in natural phosphate minerals. Their presence in water has a beneficial effect on the flora and fauna as being a nutrient salt. However, in its excess water content (> 5 mg/l), it is responsible for the acceleration of eutrophication in surface waters. Indeed, the algae use inorganic phosphorus directly by absorbing or degrading various organic phosphates and eventually proliferate in waters just because some mg/l of phosphorus ensures intense photosynthetic activity[13,15].

The figure-6 in annex shows the evolution of orthophosphates with sampling points. The results of our analyses provide values between 0 and 6.8 mg/l. In addition, we find that the effluents from the industrial zone of Kossodo contain a relatively high amount (PP1, PP2, PP3) compared to that in the water from the National Park Bangr-Weogo (PP8, PP9 and PP10). The observed data comply however with the norms in Burkina Faso, except those at the sampling points PP1, PP2 and PP3.

These results are consistent with those of previous work who found that the concentrations of major mineral elements were within the required standards[7,11].

Content of nitrates: Figure-7 in annex shows the evolution of nitrates NO_3^- with sampling points. Our data reveals that except at sampling point PP5 where the concentration is 1 mg/l, none of our samples contains nitrates. Nevertheless all values meet the current standard 50 mg/l[11].

Chemical Oxygen Demand (COD): COD is the oxygen consumption by strong chemical oxidants to oxidize organic and mineral substances in water. It allows for assessment of the pollution load of wastewater, including pollution by undesirable organic compounds. COD is one of the main measures for effluent discharge standards. It is normally measured in treatment facilities of industrial and municipal wastewater and it provides an indication of the effectiveness of the treatment process.

For this study, it is clear from our analysis in figure-8 in annex that the COD of effluents from the industrial zone of Kossodo (PP1, PP2 and PP4) is well above the standard set which is 150 mg/l[11]. This content reveals the great amount of matter channeled by the industrial effluents in Massili that can be oxidized. This is justified by the fact that the content of the COD of the water from the Park Bangr-Weogo (PP10) is low (30 mg/l) compared to that at the meeting point of industrial wastewater and Massili (PP5) which is 1070 mg/l. These results are consistent with those of previous work which revealed that the stations downstream of the affluent from Ouagadougou have a higher pollution with values for COD above 100 mg/l[9].

However, we must recognize that our data (sampling done in may) are higher than others sampling done in july-august obtained by others authors[9]. This could be explained by the difference in sampling periods because it has an influence on the COD value[14].

Biological Oxygen Demand (BOD_5): BOD is the amount of oxygen that a sample of wastewater must provide to transform by biochemical oxidation (bacterial oxidation), biodegradable organic matter. Digestion time used is 5 days hence the name BOD_5. Therefore, it is an indirect indication of bacterial activity of purification expressed in milligrams of oxygen per liter of effluent and is calculated by the difference between the measurement of oxygen content in the effluent at time 0 and that after 5 days of digestion. The biodegradability of effluent is appreciated by the ratio DCO/DBO_5: if less than 2, it is readily biodegradable; between 2 and 3, it is biodegradable; greater than 3, the effluent is found not biodegradable.

The results shown in figure-9 in annex indicate that the values of BOD_5 of all our samples are well above the standard set (40 mg/l)[11]. Moreover, the content of BOD_5 of the effluent from the industrial zone (PP1, PP2, PP3 and PP4) is very high compared to water from the park Bangr-Weogo. Our results in table 2 show that the ratio DCO/DBO_5 at the sampling sites PP2, PP4, PP5 and PP6 is between 2 and 3 and this is an indication that the effluents at these sites are biodegradable. However at PP1 which is at the outlet of the Tannery, the effluent is not biodegradable, the ratio being greater than 3. So there is pollution on each side of the meeting point Massili-industrial effluent (PP5).

Conclusion

In most cities in developing countries, industrial units or municipalities discharge without adequate treatment their wastewater into surface water bodies. Therefore, with the increase in activities related to population growth and urban industry, the quality of surface water began to fall rapidly and has become an environmental problem size. The case of the river Massili in Ouagadougou, Burkina Faso, is a good example. Indeed, Massili is the stream that receives all the wastewater from the industrial zone of Kossodo. Our study was to determine the state of pollution of its waters. The results show that some physicochemical parameters such as SPM, BOD_5, COD, dissolved oxygen and orthophosphates concentrations were above the required standard. This is not without consequences on the health of fish, wildlife and populations of the villages along the river temporarily.

Prospect: Studies should be done to complete our sampling with work over several months to take into account the effects of seasonal variation. Similarly, others parameters such as hardness, chlorophyll "a" and heavy metals should be taken into account in future analyses.

Recommendations: i. To improve the quality of effluent from the industrial zone of Kossodo, we recommend the authorities of the factories to install ponds for water treatment before its release into the wild. ii. Similarly, political will must force these plants to adequately treat their wastewater before discharging in nature; otherwise, the environment is polluted and people are prone to diseases related to these pollution.

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