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FLOCCULATION TREATMENT OF POLLUTANTS IN WASTEWATER OF "MAROUA SODECOTON" PLANT

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ABSTRACT: *This paper evaluates the physical, chemical and organic parameters of untreated and treated wastewater from the Cotton Development Corporation industry in Cameroon for short SODECOTON in the city of Maroua, and this to assess the extent of pollution of these waters as well as the effectiveness of the treatment method (flocculation-coagulation) that we performed on these waters. All the parameters (physical, chemical and organic) studied were carried out using standard methods. Physical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), suspended matter (MES) and salinity were studied. Chemical and organic parameters, including biochemical oxygen demand for five days (BOD_5), chemical oxygen demand (COD), manganese, nickel, lead, zinc, phosphate, chloride, total hardness have also been studied. The results show that all these parameters are greater than the guide values. Nitrates, copper, silver, sulfates ... were absent. The samples were subjected to physico-chemical treatments. The average abatement rates obtained for each parameter studied are: TDS: 66.83%; MES: 94.55%; MO: 99.83%; BOD_5: 93.19%; COD: 94.37%; iron: 93.58%; manganese: 98.11%; nickel: 91.53%; lead and zinc: 100%; for total hardness: 83% and phosphate: 96.91%. The results showed that flocculation-coagulation was effective in reducing the above parameters to acceptable values, even zero. This allows us to say that flocculation-coagulation can be a method of depollution the waste water from SODECOTON. It is therefore recommended to regularly monitor and treat the waste water from the Maroua industry (SODECOTON) in order to prevent the risk of contamination and water-borne diseases of the surrounding populations.*

KEYWORDS: Depollution, Physicochemical Parameters, Flocculation-Coagulation, Waste Water

INTRODUCTION

Water has always been inseparable from human activity. The industrial revolution of the 19th century, by valorizing water vapor, allowed the development of production capacity: Water has become an indispensable material for the operation of factories. Parallel to this situation, the phenomena that contribute to the degradation of water quality and subsequently to the disruption of any ecosystem multiply and intensify. The discharge of wastewater loaded with pollutants into the receiving environment without any prior treatment is a cause for growing concern given the possible undesirable effects on the environment and on health. Liquid discharges from the edible oil processing industry are a major vector of pollution and degradation of water quality (Bessix, 2002). Therefore, the implementation of measures to prevent water quality and availability is now a fundamental requirement. Moreover, the Government of Cameroon, financial institutions and the world market are now increasingly watching the efforts made by economic operators in this field and obliging them to take steps to preserve the quality of available water.

LITERATURE REVIEW

Cotton development plant wastewater has been treated with many techniques such as coagulation, flocculation, ozonation, reverse osmosis, ion exchange, flotation, electrochemical treatment, sedimentation, filtration, ultra-filtration and adsorption (Bishnu, et al, 2016, Shegani, 2013). Flocculation appears more and more as not only a clarification process but also as a specific elimination treatment capable of minimizing the amount of these pollutants (Hogg, 2000, Lind**,** 1994a**,** Lind**,** 1994b). The generally used coagulants in cotton plant effluent treatment are: commercial aluminum sulphate ($Al_2(SO_4)_3$. $18H_2O$), commercial iron sulphate ($FeSO_4.7H_2O$), commercial ferric chloride ($FeCl_3.6H_2O$), and lime (CaO) (Bishnu, et al, 2016). These waste water samples were then treated by flocculation method and the efficiency of the process evaluated by comparing the physico-chemical properties of treated waste water with results contained in the cotton plant's environmental impact study reports and standards (pollution thresholds) (CAR/PP, 2000, WHO,2004, 2017).

METHODOLOGY

Methods

The source of the water used in the plant and its pretreatment methods, the main operations requiring the use of water, the nature and points of different effluents and sewage disposal systems of the plants were identified. This was aimed at identifying the points of sampling. Water samples were collected at the lone wastewater discharge point of the plant using polyethylene bottles (washed with detergent, then with deionized water, 2M nitric acid, then deionized water again, and finally with wastewater to be collected). Theses samples were placed in an ice bath and brought to the laboratory immediately for analyses. The physicochemical properties determined were color,odor, taste temperature, pH, chemical oxygen demand (COD), biological oxygen demand (BOD_5), conductivity (EC), total suspended Solids (TSS), total dissolved solids (TDS), organic mater and chloride. The geographical coordinates's locations of sampling are 10 °35.144 'N and 014°18.864'E, Altitude 404 m determined by GARMINetrex 10 GPS.

Analytical Methods

All analyses were performed on raw waste water collected from the four tanning stages shown in figure 3 as well as their treated samples.

The Physico-chemical parameters such as temperature, pH and conductivity (μScm^{-1}) were measured in situ using an Extech pH-conductibility EC 500 multiparameter while Total suspended solids (TSS) was determined using APHA method (APHA, 1985).

Total Hardness was determined by complexometric titration using Eriochrome Black-T as an indicator by EDTA method and Chloride was estimated by Mohr's method using $AgNO_3$ solution and Potassium Chromate as an indicator (APHA, 1985)

The amount of dissolved oxygen was determined by acid-medium determination (H_2SO_4) with a solution of sodium thiosulfate in the presence of manganese sulphate (APHA, 1998).

The chemical oxygen demand was determined by acid oxidation using an excess of potassium dichromate at the temperature of 148 °C of the oxidizable materials under the reaction conditions in the presence of silver sulphate as catalyst and sulphate of mercury (APHA, 1998).

The BOD_5 was measured using a device that records the amount of oxygen supplied to restore the initial pressure of oxygen as needed: it is the respirometric system of Sierp.

Chloride was estimated by Mohr's method using AgNO3 solution and Potassium Chromate as an indicator (APHA, AWWA, WEF, 1998).

Coagulation/Flocculation Treatment of Waste Water Samples

Flocculation is one of the effective methods for removing these colloidal particles in water. It constitutes all physico-chemical phenomena leading to the aggregation of stabilized particles to form flakes or flocs. It allows the formation of aggregates by accelerating phase separation (CARDOT, 1999).

In our tests, aluminum sulfate coagulant reagent was prepared by dissolving aluminum sulfate powder ($Al_2 (SO\ 4)_3$, $18H_2\ O$) in distilled water. A 500 mL sample of the effluent was collected from each of the sampling points (soaking, liming, deliming and vegetable tanning stages) using a polyethylene bottle previously cleaned with dilute nitric and effluent of the sampling point concern. 500 mg of coagulant reagent was mixed well with 500 mL of the effluent sample for 15 minutes. The mixture was then allowed to stand undisturbed for 24 hours in the dark at room temperature for proper settling and interaction with the coagulant. The supernatant liquids were separated from the deposited sludge by decantation and used for various physico-chemical analyses.

RESULTS

The results of the analysis of four point's samples waters of the cotton development plant of Maroua prior to treatment are presented in Table 1 while results obtained after Coagulation /Flocculation treatment are presented in Table 2. These results are compared to WHO standards which indicate the acceptable limit for domestic use of this water.

Table 1: Physico-Chemical Characteristics of the Untreated Cotton Plant Waste Water

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	WHO standard (WHO, 2004, 2017)
Temperature (°c)	32	32	33	32	25
pH	6.95	10.25	11.25	7.2	6.5-8.5
Conductivity (µS/cm)	699	1407	8320	3400	400
Organic Mater (OM)	43.4	45.5	44.2	40.6	
TSS (mg/L)	25500	12000	23500	5000	100
COD (mg O_2/L)	1604.3	1874	1330	1294.67	44
BOD_5 (mg O_2/L)	511	574	560	486	50
Hardness (mg/L)	61.44	43.008	18.432	15.36	100
Chloride(mg/L)	2662.5	8875	3550	1775	250

Table 2: Physico-Chemical Characteristics of the Treated Cotton Plant Waste Water

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	WHO standard (WHO, 2004, 2017)
Temperature (°c)	26.5	26.9	26.9	26.5	25
pH	7.8	7.94	8.57	7.87	6.5-8.5
Conductivity (µS/cm)	1994	1463	1111	2720	400
Organic Mater (OM)	0.05	0.07	0.1	0.08	
TSS(mg/L)	500	490	100.7	25.8	100
COD(mg O_2/L)	83	95	88	77	44
BOD_5(mg O_2/L)	35	40	38	32	50
Hardness (mg/L)	46.08	30.720	12.288	6.144	100
Chloride(mg/L)	0	0	0	0	250

DISCUSSION

In general, the parameters which influence in the treatment of water by coagulation-flocculation are the pH and the dose of coagulant injected; however, it is also possible that, the nature of the coagulant, the time and speed of coagulation, the ionic strength, temperature… come into play.

Influence of Coagulants

To determine the optimal dose of coagulant, we performed the Jar Test on our wastewater with increasing doses of alumina sulfate. Our samples are treated with the coagulant ($Al_2(SO_4)_3$, xH_2O) with concentrations ranging from 0 to 8 mg.L^{-1} and for each dose, different parameters are measured.The addition of Al^{3+} facilitates coagulation due to the effect linked to the increase in ionic strength (compression of the diffuse layer), the coagulation mechanism is based on neutralizing the negative charge of stable particles by adsorption of cations on their surface. For an optimal concentration of alumina sulfate the percentage reduction in turbidity is higher. On the other hand, the overdose of coagulant, source of cations, can result in too much adsorption of cations and reverse the charge of the particles which then become positive. The particles would thus be profitable (Pallier, 2008). The results obtained indicate that the optimal dose of coagulant for these four samples is on average 5 $mg.L^{-1}$

Influence of pH

The objective of coagulation is to destabilize the colloids which have a negative charge thus promoting their agglomeration which can be decanted more easily. The pH of water has an important impact on the efficiency of coagulation (Tardat-Henry, 1989). For the different samples, the optimal pH varies between 5 and 7. Indeed, several researchers (Maulding and Harris, 1968, Van Benshoeten and Edzwald, 1990, Hanson and Cleasby, 1990, Van Benshoeten et all, 1992, Kang et all, 1995) have shown that each coagulant requires an optimal pH zone corresponding to solubility. The results obtained confirm the bibliographic data concerning the elimination of colloidal materials for pHs generally between 5 and 7 depending on the nature of the coagulant (Semmens and Ayers, 1985; Van Breemen et all, 1979; Jekel, 1986; Rahni, 1994). Since the pH also conditions the chemical forms of aluminum, it is obvious that the mechanisms involved in the elimination of these compounds can be very diverse.

Influence of Flocculants

From the optimal concentrations of coagulants determined above as well as from pH, a series of tests with different doses of flocculant (activated silica) were carried out. This series of tests is carried out to approach the optimal concentration of flocculant with a coagulant concentration of 5 mg / L and a pH of 5 or 6 depending on the sample. The results show that for the different samples treated, the best performance is obtained for a dose of activated silica between 2 and 3 g. These results confirm the conclusions of the statistical analysis. The excess of activated silica would cause additional erosion of the flocs, while an underdosing would be responsible for poor ballasting of the flocs formed.

Influence of Time of Agitation

The coagulation step requires a very short time for the destabilization of colloids. The agglomeration of colloids in flakes of sufficient size and rigidity is an action necessary to facilitate any solid-liquid separation, whether it is a matter of decantation or filtration. This agglomeration of destabilized colloids requires two main functions:

- an intense interaction between the discharged particles in order to increase the probability of encounter and collisions, which will allow the formation of flocs.

- avoid the destruction of flocs formed mechanically and we know that the number of collisions between particles is proportional to the speed gradient, but the shear forces are also (Pallier, 2008). For the four cases, a better reduction of turbidity, at a time which varies between 15 and 16 min.

Colour et Odour

The cloudy color and the nauseous odor of the waste water of the Maroua SODECOTON show a pollution of the receiving environment and thus not only having negative effects on the health of the workers but the environment as a whole. After the flocculation treatment, there was an effective decrease in the odour and colour of this water.

pH

The values obtained in the sample 2 and sample 3 are within the standard, but those obtained in sample 1 and sample 4 are higher than the WHO standard (6.5 - 8.5), Table 1 for untreated waste water samples. It appears therefore that these waters are alkaline or acid according the samples. The pH values obtained are comparable to those found elsewhere for cotton plant wastewater (Ezzaouaq, 1991, El Blidi and Fekhaoui, 2003, Himmi et al, 2003). From Table 2, it can be seen that Flocculation treatment improves the pH values to recommended standards (WHO, 2004, 1987, Semerjian and Ayoub, 2003).

Conductivity

Results of conductivity measurements for untreated samples ranged from 699 to 8320 µS/cm (Table 1). These results show a strong mineralization in these waters and therefore a high concentration of dissolved salts. These high values of conductivity indicate a significant use of salts during the activity process. These values remain well above the WHO standard value 400$\mu S.cm^{-1}$ for surface water. It is observed from Table 2 that Flocculation considerably increases the activity of those ions present in sample 1 and sample 2 as they had remained inactive due to the high concentration of organic matter.

Total Suspended Solids

The concentrations of total suspended solids recorded in the different samples varied between 5000 and 25 500 $mg.L^{-1}$ (Table 1) which are well above the standard of 1000 $mg.L^{-1}$ (WHO, 2004).These high levels of suspended matter can be considered as a form of pollution (Rodier, 1984). Such an increase can lead to a warming of the water, which will have the effect of reducing the quality of the habitat for the cold-water organisms (Hebert and Legre, 2000). The treatment of these waters by flocculation reduces the concentrations of total suspended solids by approximately 94.55% (Table 2).

Chemical Oxygen Demand (COD)

COD is a measurement of the oxygen equivalent of the organic matter in a sample which is affected by oxidation of a strong chemical oxidant (Abba et al, 2018). Obtained values of this analysis varied from 1294.67 $mgO_2.L^{-1}$ to 1874 $mgO_2.L^{-1}$, well above the maximum value of 250 $mgO_2.L^{-1}$ expected by WHO, Table 1. These high values of the chemical oxygen demand reflect the presence of a very large amount of organic matter and particularly presence of biologically resistant organics, hence the toxic nature of these effluents. Thus, the water of the SODECOTON of Maroua constitutes a source of pollution for the receiving environment (Desjardins, 1999). The flocculation treatment was able to reduce about 94.37% on average of COD (Table 2), thus decreasing the toxicity of these waters.

Biological Oxygen Demand (BOD_5)

BOD_5 refers to quantity of oxygen needed y microorganisms for biological decomposition of dissolved solids or organic matter in effluents under aerobic conditions (Abba et al, 2018). Values ranging from 486 to 574 $mgO_2.L^{-1}$ were obtained, indicating an organic pollution WHO, 2004). The high content of BOD_5 could be explained by the abundance of organic matter from cotton seeds and from treatments which plantations underwent. The physicochemical treatment applied to this water decreases the organic load to about 93.19% and thus brings back water that is highly toxic to water that is moderately toxic to the environment.

Chloride

The chloride concentrations found in the waters of the SODECOTON of Maroua (Table 1) ranged from 1775 to 8875 mgL^{-1}. The values obtained are higher than the WHO standard (Table 1). The flocculation treatment allows a total reduction of this ion.

Hardness

It is observed from Table 1 that all samples have total hardness values below WHO standard (Table 1). The aluminum sulphate used for flocculation precipitates these calcium and magnesium ions in the form of calcium and magnesium sulphate. Hence, the almost complete elimination of hardness. The flocculation treatment reduces the hardness by about 30% on average.

CONCLUSION

The physico-chemical characterization of waste water collected from four samples of the cotton development plant of Maroua before and after Flocculation treatment was undertaken in this study. Results obtained where compared to WHO standards for domestic water quality to evaluate the potential risk of these waste water to the environment and human health. The cotton development plant of Maroua uses a large number of chemicals and produces huge amounts of wastewater and solid waste. During this study, we were able to highlight the toxicity of four effluents, high consumers of water. The results obtained during laboratory and field analyses of certain physico-chemical parameters such as: conductivity, pH, color, odor, TSS, COD, BOD5 and chloride ion are higher than those predicted by the international standard (CAR/PP, 2000). These waters therefore constitute a pollution load for the receiving environment. The results obtained made it possible to classify these four samples in order of toxicity. The treatment of these waste waters by flocculation using aluminum sulfides considerably reduces the concentrations of certain pollutant loads such as TSS, chloride (95%), COD, BOD5, (93%); but remains less effective on others such as hardness (30%). The flocculation treatment thus considerably the toxicity of theses effluents, especially its organic load.

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