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MONITORING OF PHYSICO-CHEMICAL CHARACTERISTICS AND PERFORMANCE EVALUATION OF A WASTEWATER TREATMENT PLANT IN ALGERIA

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ABSTRACT

Reduction of pollutants in the wastewater down to permissible concentrations is necessary for the protection of the environment. Activated sludge is the most common biological technology used for domestic wastewater treatment in Algeria. Hence, it has been adopted since the 2001 by the Office National Sanitation (ONA). The main objective of this study was to evaluate the removal efficiency and performance of effluent treatment plant in Algiers. The results revealed that the untreated wastewater has high inorganic and organic pollution. The average concentrations decreased as follow: ammonia from 18.55±3.99 mg/L to 2.90± 2.65 mg/L, BOD from 59.91± 6.94 mg/L to 3.11± 0.66 mg/L, nitrates from 48.58±6.10 mg/L to 2.64±0.64 mg/L, suspended matter from 183.6± 30.1 mg/L to 14.7±3.6 mg/L, turbidity from 71.74±15.68 mg/L to 3.93±0.76 mg/L and COD from 219.3±19.9 mg/L to 31.2±1.0 mg/L. In the present study, a significant ($p< 0.001$) decrease was observed in the physico-chemical parameters viz. NH_4^+ (99.8%), BOD_5 (94.7%), NO_3^- (94.1%), suspended matter (92.9%), turbidity (91.8%), COD (85.4%), total phosphorus (46.9%) and orthophosphates (21.3%) to reduce them to acceptable values not exceeding the permissible limits as per WHO standards.

Keywords: activated sludge treatment, Algiers-Algeria, WWTP, physico-chemical parameters.

1 INTRODUCTION

Wastewater is becoming increasingly important in integrated water resources management because of the scarcity of water resources and the need of environmental protection (Xu et al. 2002). WWTPs can have significant impacts on receiving waters despite the extensive treatment of wastewater prior to discharge. Discharge of untreated effluent wastewaters into water bodies may put at risk riparian communities that depend on these waters for domestic and personal use (Tchobanologous et al. 2003). The protection of receiving waters is essential to prevent eutrophication and oxygen depletion in order to sustain fish and other aquatic life. The need for greater nutrient removal efficiency at WWTPs is evident (Zhou and Smith 2002; Pagilla et al. 2006) as increased eutrophication due to nutrient inputs is a leading cause of aquatic impairment (Correll 1998; Magnien et al. 1992; Rabalais 2002). Effluent discharges from WWTPs can influence both water quality and overall hydrologic characteristics of receiving waters.

The water purification in Algeria is new, it is governed by the Office National Sanitation (ONA), created in 2001 under the Ministry of Resources water directed several WWTPs. But, the reuse of treated wastewater for irrigation is not developed in Algeria. This is because these wastewaters are discharged into the receiving environment. Inadequately treated, wastewater effluent is harmful to the receiving aquatic environment.

No past extensive study has been carried out to assess the efficiency and quality of this WWTP. In order to preserve the quality of water masses, and to estimate the pollutant removal efficiency and reduce the deterioration of the natural environment, alternative water supplies should be required.
This study focuses on the characterization of the physico-chemical effluents (pH, electrical conductivity, turbidity, suspended matter, COD (Chemical Oxygen Demand), BOD_5 (Biochemical Oxygen Demand), ammonium, nitrite, nitrate and phosphates in raw and treated wastewater of Béni Messous Wastewater Treatment Plant.

2 MATERIAL AND METHODS
2.1 Study area

Wastewater treatment plant (WWTP) namely Béni Messous with conventional activated sludge system was monitored. This WWTP is located at 20 km east of Algiers. Mechanical-biological wastewater treatment plant with sludge stabilizing tank started in 2007. The treatment plant was connected for Staouéli, Béni Messous, Chéraga, Ain Benian and one part of Dély Brahim. WWTP consist of primary and secondary treatment steps. After treatment, the water is released into the Béni Messous river that joined Mediterranean Sea. The treatment capacity of the WWTP was about 50400 m^3 day^{-1} (Abdessemed et al. 2009).

2.2 Sampling and physico-chemical analysis

Sampling was done from February to August 2013 totalizing 12 samplings. Raw influent and final effluent samples of the plant were collected in 1 L bottles and were preserved at 4 °C during transportation to the laboratory. They were then immediately analyzed for total suspended matter (MES), nitrites (NO_2^-), nitrates (NO_3^{2-}), ammonia (NH_4^+), orthophosphates (PO_4^{3-}), total phosphorus (PT), chemical oxygen demand (COD) and biochemical oxygen demand (BOD5). The parameters pH, conductivity (EC) and temperature (T) were determined in situ. The analytical methods used in the physico-chemicals laboratory are described as follows:

Table1. Procedures used for the analysis of raw and treated wastewater

Analytical Parameters	Methods	Reference
pH	pH meter Sensio (Hach)	NA. 751/1990 pH meter
EC	Conductimeter (Mettler Toledo MC226)	NA. 749
Turbidity	Turbidimeter (Hach 2100N)	NA 746 ISO 7027
Suspended matter	Filtration method	ISO 11923
BOD5	5-day BOD test	ISO 5815
COD	Closed Reflux, Titrimetric Method	ISO 6060
Nitrates	NO3-N Salicylate method Spectrophotometer (HACH DR 2800-2400)	SEAAL (2009)
Nitrites	Spectrophotometric method	ISO 6777
Ammonia	spectrometric method	ISO 7150/1
Orthophosphates	spectrometric method	NF ISO 6878P

2.3 Efficiency of Removal

Treatment efficiency was assessed for all monitored pollution indicators. Calculated treatment efficiency of indicators turbidity, suspended matter, BOD, COD, NO_2^-, NO_3^{2-}, NH_4^+, PO_4^{3-} and total phosphorus PT was compared with the permissible minimum treatment efficiency of discharged waste water given by WHO.
The efficiency of cleaning process R (%) is defined as the ratio between removed concentration of polluting and their initial concentration. The efficiency of removal can be calculated using the following formula:

$$R = \frac{P_i - P_0}{P_i} \times 100$$

Where: P_i is the mass concentration of component A at the system output (mg L^{-1}) and P_0 is the mass concentration of component A at the system input (mg L^{-1}).

2.4 Statistical analysis

The comparisons of the various parameters (before and after treatment) were performed using t-test for dependent samples; the Wilcoxon matched pairs tests were using in cases of severe violations to normality or heterogeneity of variances. The difference were considered significant at $p<0.05$.

3 RESULTS

The values of different physico-chemical parameters recorded from the wastewater samples are summarized in Table 2.

Table 2. Comparison between influent and effluent data using t-test or Wilcoxon Matched Pairs tests for Wastewater Treatment Plant

Parameters		Min	Max	Median	Average+SE	Removal (%)	p
T (°C)	Influent	11.30	26.50	15.60	17.50±1.42		
	Effluent	13.40	25.00	21.75	19.63±1.65		
pH	Influent	6.26	8.18	7.74	7.70±0.14		
	Effluent	7.15	7.94	7.71	7.69±0.06	1.74	0.33
EC (µS cm^{-1})	Influent	1260	1578	1449	1411.17±36.83		
	Effluent	1086	1606	1399	1350.08±47.72	5.32	0.14
Turbidity (NTU)	Influent	20.70	161	51.73	71.74±15.68		
	Effluent	1.44	10.20	2.69	3.93±0.76	91.8	0.0033
MES (mg L^{-1})	Influent	65.33	366	172.26	183.55±30.13		
	Effluent	2.63	39.80	8.63	14.74±3.60	92.9	0.00015
COD (mg L^{-1})	Influent	129.02	390	216.52	219.30±19.85		
	Effluent	29	38.40	29.00	31.19±1.02	85.4	0.0022
BOD_5(mg L^{-1})	Influent	25.49	110.21	56.27	59.91±6.94		
	Effluent	0.84	9.21	2.65	3.11±0.66	94.7	0.0033
NH_4^+(mg L^{-1})	Influent	0.19	42.50	14.01	18.55±3.99		
	Effluent	0.01	32	0.06	2.90±2.65	99.8	0.0033
NO_3^{2-}(mg L^{-1})	Influent	11.07	89.26	48.62	48.58±6.10		
	Effluent	0.40	6.95	3.14	2.64±0.64	94.1	0.0022
NO_2^-(mg L^{-1})	Influent	0.01	1.80	0.17	0.51±0.18		
	Effluent	0.04	4.26	0.27	0.67±0.34	50	0.76
PT(mg L^{-1})	Influent	2.19	7.21	3.65	3.85±0.35		
	Effluent	1.08	5.24	1.90	2.15±0.31	46.9	0.0029
PO_4^{3-}(mg L^{-1})	Influent	0.25	1.81	0.59	0.78±0.15		
	Effluent	0.12	2.80	0.44	0.90±0.23	21.3	0.31

4 DISCUSSION

The mean temperature recorded for the raw wastewater was 17.50±1.42°C while the water temperature in the treated system was between 13.40 °C and 25 °C (Table 2) within acceptable limits of no risk (15 to 25°C). This range of temperature was adequate for efficient removal of pathogens and nutrients in the wastewater (Belmont et al. 2004).

All wastewater samples produced in Béni Messous Wastewater Treatment Plant have pH ranging from 7.70±0.14 and 7.69± 0.06 which indicates that the treated municipal wastewater is slightly alkaline in nature. The normal pH range for discharging water is from 6.5-8.5 (WHO, 2004).

Regarding to the electrical conductivity of the water samples was not varied significantly ($P > 0.05$) and ranged from 1260 to 1570 µS cm^{-1} throughout the study period with the treated final effluent samples ranging between 1086 and 1606 µS cm^{-1} (Table 2). The conductivity values obtained in this study were higher to the findings of previous study (Igbinosa and Okoh, 2009).

The turbidity profile varies significantly ($P< 0.05$) amongst the sample points throughout the study period. The average value of turbidity during the monitored period was 71.7± 15.68 NTU at the inflow and 3.93± 0.76 NTU at the outflow. The total efficiency of wastewater treatment plant for turbidity reducing was 91.8%. The turbidity values obtained from the raw water was less than WHO standard of 5 NTU (WHO, 2004).

The suspended matter (MES) profile of the treated final effluent and raw wastewater vary significantly ($P < 0.05$).The average value of suspended matter (MES) during the monitored period was 185.55± 30.13 mg L^{-1} at the inflow and 14.74± 3.60 mg L^{-1} at the outflow. The efficiency of wastewater treatment plant for suspended matter reduction was 92.9% (Table 2). The permissible treatment efficiency, determined for the discharge of wastewater must be at least 30 mg L^{-1}. Waste water treatment plant meets the mandated with the permissible limits as per WHO.

The Chemical Oxygen Demand (COD) was defined as the amount of oxygen required by organic material in water for its oxidation by strong chemical oxidant. This test was used to measure the pollution values in wastewater. The average value of COD during the monitored period was 219.30± 19.85 mg L^{-1} at the inflow and 31.19± 1.02 mg L^{-1} at the outflow. Waste water treatment plant meets the mandated limit as per WHO standards (90 mg L^{-1}). The COD reduction obtained is similar to that found by Gesberg et al. (1986) and higher than that obtained by Urbanc-Bercic (1994).

In this study, the average value of BOD was 59.19± 6.94 mg L^{-1} at the inflow and 3.11 ± 0.66 mg L^{-1} at the outflow. The total efficiency of WWTP for BOD reducing was 94.7% and changed significantly ($P < 0.05$) (Table 2) indicating a high performance for reductions in BOD. The permissible minimum treatment efficiency, determined for the discharge of waste water, must be 30 mg L^{-1} in the case of BOD. Waste water treatment plant meets the mandated limit as per WHO standards.

The average value of ammonia nitrogen during the monitored period was 18.55± 3.99 mg L^{-1} at the inflow and 2.90± 2.65 mg L^{-1} at the outflow from the WWTP. The efficiency of the WWTP for ammonia nitrogen reducing was 99.8%.

The average value of nitrate nitrogen was 48.58± 6.10 mg L^{-1} at the inflow and 2.64± 0.64 mg L^{-1} at the outflow. The efficiency of the WWTP for nitrate nitrogen reducing was 94.1% and changed significantly ($P < 0.05$). The nitrate nitrogen levels obtained during the study period did not exceed the regulatory limits and is not considered to pose a problem to communities when the receiving water bodies are used for the domestic and recreational purposes. However, it is important to note that the nitrate nitrogen levels in the final effluents could be a source of eutrophication for the receiving water bodies.

The average value of nitrite nitrogen was 0.51± 0.18 mg L^{-1} at the inflow and 0.67± 0.34 mg L^{-1} at the outflow from the WWTP. The efficiency of the WWTP for nitrite nitrogen was 50%. The results shows, that there was an increased level of this indicator at the outflow from the WWTP by 0.67 mg L^{-1}. The treated wastewater not differs significantly ($P > 0.05$) (Table 2).

The average value of the total phosphorus during the monitored period was 3.85± 0.35 mg L^{-1}at the inflow to the WWTP and 2.15 ± 0.31 mg L^{-1} at the outflow from the WWTP and differs significantly ($P < 0.05$). The efficiency of the WWTP for the total phosphorus reducing was 46.9%.

The average value of orthophosphates was 0.78± 0.15 mg L^{-1}at the inflow and 0.90± 0.236 mg L^{-1}at the outflow from the WWTP and not differs significantly ($P > 0.05$). The efficiency of the WWTP for this parameter was only 21.3%. The results showed that there was an increased level of this indicator at the outflow from the WWTP by 0.90 mg L^{-1}. The principal phosphorus compounds in wastewaters are generally orthophosphates often linked to smaller amounts of organic phosphorus (Grubb *et al.* 2000). Phosphorus is essential nutrients to plant life, but when found in excessive quantities; they can stimulate excessive and undesirable plant growth such as algal blooms. Eutrophication could adversely affect the use of rivers and dams for recreation purpose.

The typical COD/BOD5 ratio of domestic wastewaters is usually in the range 1.25 to 2.5. The influent wastewater of this WWTP exhibited a COD/BOD_5 ratio range 2.62-6.67 (mean 3.89±0.45) before purification to ratio range 6.3-34.5 (mean 15.11±2.83) after purification, which indicates a purified water and also a relatively higher proportion of non biodegradable content in raw wastewater. As a consequence, the efficiency of BOD removal is higher than that of COD removal**.**

Treated water showed highly significant decreases ($p<0.001$) for some physico-chemical load reducing them to acceptable values not exceeding the permissible limits as per WHO standards. Order of reduction in the STP was found to be ammonium > biochemical oxygen demand (BOD) > nitrates > suspended matter > turbidity > chemical oxygen demand (COD) > PT > PO_4^{3-}.This indicates efficient removal of mentioned parameters from the Béni Messous WWTP.

CONCLUSION

This study indicates efficient removal for some physico-chemical parameters from the STP wastewater. The results showed that the effluent physico-chemical quality was appropriate for discharging. Therefore, in order to protect the health of the consumers and the farm workers, advanced treatments, such as tertiary treatment, sand filtration and UV disinfection, are recommended.
It is also recommended that wastewater effluents should be routinely monitored to ensure that strict adherence to effluent discharge standards is met.

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