

CHARACTERISATION AND RATIONALISATION OF URBAN EFFLUENTS IN THE TIZI-OUZOU REGION (ALGERIA)

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ABSTRACT

The knowledge of the composition of urban wastewater discharges is an essential parameter to ensure the relevance of the choice and sizing of appropriate treatment systems to guarantee the quality objectives of the receiving environments. The results obtained allowed us to calculate the daily production per capita of physical, hydrocarbon, nitrogen and phosphorus pollution, specific to the study area. The values of the ratios calculated are : 30.02 g/IE/d for SM, 66.64% less than the reference discharge, i.e., 90 g/IE/d; 33.97 g/IE/d for BOD₅, 43.38% less than the reference discharge, i.e., 60 g/IE/d; 53.80 g/IE/d for COD, 55.17% less than the reference discharge, i.e., 120 g/IE/d; 3.14 g/IE/d for TN, 68.28% below the reference value of 9.9 g/IE/d and 1.07 g/IE/d for TP, also 53.50% below the reference value of 2 g/IE/d. These results show that the calculated values reflect a different reality than the reference values. This approach could optimise the choice and sizing of treatment works.

Keywords: Urban waste, normalisation, inhabitant equivalent.

ديهية وآخرون

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توصيف وترشيد النفايات السائلة الحضرية في منطقة تيزي وزو (الجزائر)

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باحث

قسم العلوم الزراعية - كلية العلوم البيولوجية و العلوم الزراعية - جامعة مولود معمري تيزي وزو

المستخلص

تعد معرفة تركيبة مياه الصرف الصحي عامل أساسي لإختيار الطريقة المناسبة للمعالجة وذلك من أجل ضمان جودة البيئة المستقبلية. النتائج التي تم الحصول عليها، سمحت لنا بحساب الإنتاج اليومي الفردي لتلوث الفزيائي، الهيدروكربوني، النيتروجيني والفسفوري الخاص بمنطقة الدراسة. قيم النسب المحسوبة هي : 30.02 غ/ف/ي للمادة المعلقة، أصغر ب 66.64 % من قيمة المرجع 90 غ/ف/ي، 33.97 غ/ف/ي للطلب البيوكيميائي للأكسجين، هذه القيمة أصغر ب 43.38 % من قيمة المرجع 60 غ/ف/ي، 53.80 غ/ف/ي للطلب الكيميائي للأكسجين، هذه القيمة أصغر ب 55.17 % من قيمة المرجع 120 غ/ف/ي، 3.14 غ/ف/ي للطلب النيتروجيني، هذه القيمة أصغر ب 68.28 % من قيمة المرجع 9.90 غ/ف/ي و 1.07 غ/ف/ي للطلب الفوسفوري، هذه القيمة أصغر ب 53.50 % من قيمة المرجع 2 غ/ف/ي. تُظهر هذه النتائج أن القيم المحسوبة تعكس حقيقة مختلفة عن تلك الخاصة بالقيم المرجعية. هذا النهج يمكن أن يحسن إختيار هياكل العلاج وحجمها.

كلمات مفتاحية: النفايات الحضرية، تسوية، ما يعادل الفرد.

INTRODUCTION

With insufficient, irregular and unevenly distributed rainfall, the average annual mobilisation is around 300 m³ per year and inhabitant. Algeria, like the hydro-sensitive countries, is faced with a severe water deficit (3). Add to this the conventional water resources, which are approaching their qualitative limits. It is obvious then that the recourse to purified and treated non-conventional water is becoming more and more an attractive and unavoidable alternative (7; 11; 15). Faced with this situation and preserving conventional water resources for the most important uses, such as drinking water supply (11), the public authorities are directing their efforts towards mobilising and developing water treatment plants. In this respect, the number of functional WWTPs is currently 166 and will reach 272 by 2020, with a treatment capacity of 1 billion m³ per year (12). Urban wastewater treatment is essentially based on the actual quantification of the WWTP sizing parameters, i.e., SM, BOD5, COD, TN and TP. Knowing that the concentration and quantitative flows of these parameters depend directly on the socio-economic model of the connected population (13). The realisation of WWTPs in Algeria is based on European or American standards whose way of life and industry is totally different from ours. Hence, the standards used may be far from the reality of our urban discharges. In addition, a realistic estimate of the quality parameters of domestic wastewater would be an essential asset for the choice and sizing of treatment systems. Therefore, it is important to implement a national standardisation strategy based on the real values of pollution parameters in inhabitant equivalents per clean day for our discharges. This vision would allow an optimisation of the treatment works on the technical and economic levels. This study aims to characterise the raw urban effluents of six WWTPs studied in the Wilaya of Tizi-Ouzou. This examination will allow us to calculate the real daily production of physico-chemical pollution in inhabitant equivalent (IE) specific to the raw effluent of the study area.

MATERIALS AND METHOD

Presentation of the study area

The six WWTPs studied are located in the Tizi-Ouzou region (Figure 1). This region has two watersheds with a total area of 2,900 km² and a total population of 1,250,000 inhabitants, 88% of whom are connected to the sewerage system. This region is located between the polar and tropical air masses from October to April when the arctic air masses generally prevail and determine a high-water period. During the other months of the year, the wet polar air masses retreat to make way for the warmth of a low-water period. The average rainfall is between 700 and 1,000 mm of water per year, making this region one of Algeria's water centres. With an appreciable rainfall and a favourable topography, this region has a 180 hm³ dam, two dams under construction of 90 and 43 hm³ respectively and others in prospect. To protect the important hydrographic basin of this locality from urban discharges, 8 WWTPs have been set up, and 6 are in prospect in the short term.

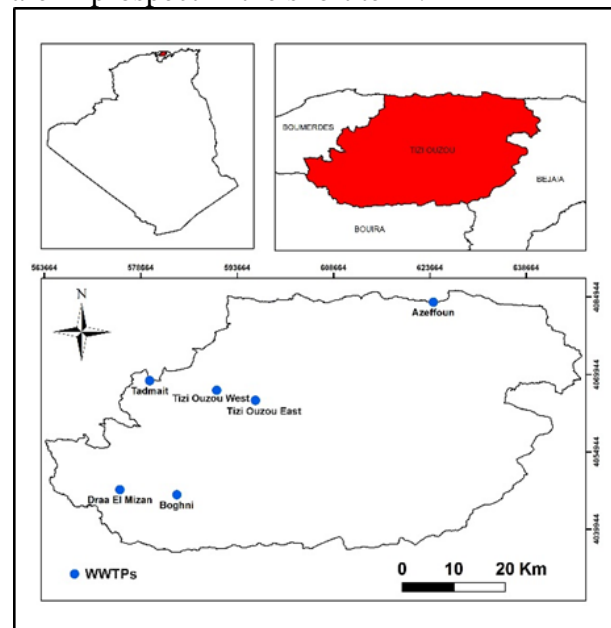


Figure 1. Geographic location of the study area.

Water consumption and sanitation

With a rugged topography and a difference in altitude of nearly 2000 meters, the daily water supply in the locality remains difficult and energy-consuming. However, it is noted that the average supply of drinking water is 150 litres per capita per day. The distribution can sometimes be discontinued for these reasons of difficult terrain. Given the water vocation of

the town, an important sanitation network is being set up, covering 88% of the population, with a total of 21 WWTPs in the medium term. It should be noted that with the current coverage, 81.52% of urban wastewater is not treated.

Wastewater sampling and analysis

The monitoring of the parameters SM, BOD₅, COD, TN and TP was carried out over a period of two years, 2019 and 2020. The sampling frequency was one weekly sample, for raw wastewater, at the head of the plant. The samples were of the composite type, 24-hour balances. They were prepared by mixing three spot samples at 08:00, 13:00 and 18:00, of constant volume, transported in a cooler to the laboratory and then stored at 04°C for the next day (ISO 5667-1 standard, ISO 5667-3 standard) (5; 16). All analyses were carried out in the water treatment laboratory of our faculty. SM was determined by the filtration method. The biochemical oxygen demand was determined by the manometric method using a BOD meter type TS 606/2-i. COD was measured by a COD meter type PB-CSB/12M.

Table 1. Daily accumulations of raw effluent from the studied wastewater treatment plant

WWTP	Nominal capacity (IE)	Nominal flow rate (m ³ /d)	Theoretical flow rate (m ³ /d)	Actual population connected	Actual flow (m ³ /d)
Draa El Mizan	30 000	4 500	3 600	26 467	3 176
Boghni	13 000	1 950	1 560	16 976	2 037.08
Azeffoun	20 000	3 000	2 400	11 832	1 419.88
Tadmait	13 000	1 950	1 560	6 852	822.23
West Tizi-Ouzou	25 000	3 750	3 000	39 425	4 730.95
East Tizi-Ouzou	120 000	18 000	14 400	136 401	16 368.08

Suspended matter

The SM content of the raw effluent in the study area shows a close inter-site agreement of the recorded values. The averages vary between 212.65 and 291.10 mg/l, with an overall average of 250.19 mg/l (Figure 2). This average is 58.30 % lower than the guide value of direct discharges, which is 600 mg/l (9) and those found in Medea 529.67 mg/l (6), Azilal 559.39 mg/l (8) and higher than that found in Oujda 144 mg/l (1).

Nitrates and total phosphorus were determined by a HANNA multi-parameter photometer model HI 83214. Nitrite was determined by a UV-visible spectrophotometer and Kjeldhal nitrogen by a mineraliser type InKjet 1225 P.

RESULTS AND DISCUSSION

Characterisation of urban discharges in the study area

During this study, we monitored weekly averages of physicochemical parameters SM, BOD₅, COD, TN and TP of WWTP inlet effluents studied over a period of two years, 2019 and 2020. The aim was to estimate the gross urban discharge of the said locality in population equivalent (PE). First, we measured the real flow of the studied WWTPs, compared to the theoretical flow, which is calculated based on a return to the WWTP of 80% of the daily supply of water, i.e., 120 litres per inhabitant per day. Then we measured the nominal flow of the WWTPs, which is calculated based on the overall supply of water, i.e., 150 litres per inhabitant per day (Table 1).

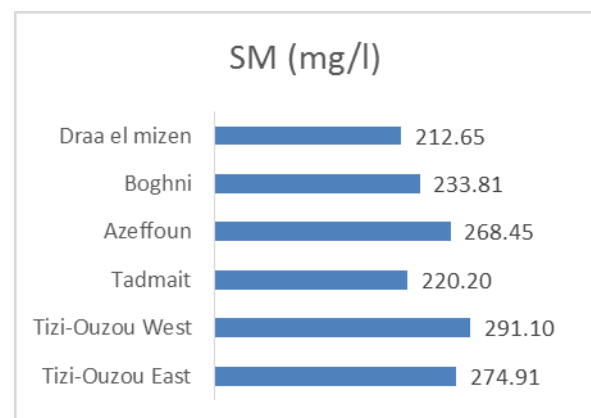


Figure 2. Average SM concentrations of wastewater in the study area (mg/l).

Biochemical oxygen demand

The BOD₅ values recorded range from 147.31 to 449.09 mg/l, see figure 3. The overall average being 283.07 mg/l, also lower than the guide value for urban wastewater, which is 500 mg/l (9). This concentration shows the predominance of the domestic character of these discharges. This value is also higher than that found in Oujda 181 mg/l (1). On the other hand, it is lower than that found in Sanaa 1137 mg/l (14).

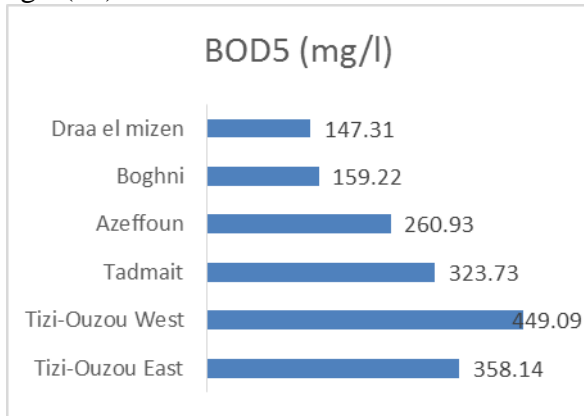


Figure 3. Average BOD₅ concentrations of wastewater in the study area (mg/l).

Chemical oxygen demand

Figure 4 shows an approximation of COD values which vary between 339.91 to 589.57 mg/l with an overall average of 448.32 mg/l. This average, which represents less than 55.17% of the guide value for raw urban wastewater, i.e., 1000 mg/l (9), also explains the domestic aspect of the effluents. Nevertheless, the average value is higher than that found in Oujda 313 mg/l (1).

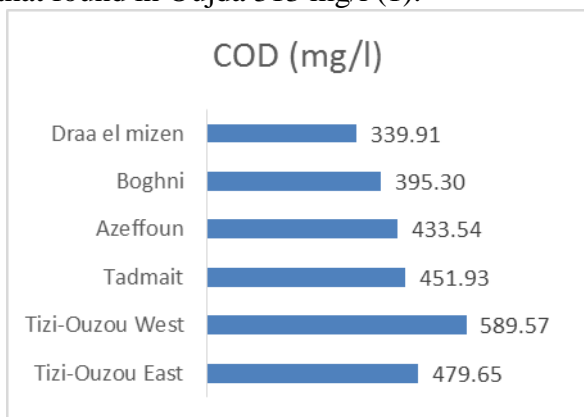


Figure 4. Average COD concentrations of wastewater in the study area (mg/l).

Nitrogen

In general, the nitrogen discharged by agglomerations is quickly found in the sewerage system in its two organic and

ammoniacal forms, with a slight predominance of the former at the beginning. The transit in the network with the secretion of urease by the presence of ammonifying bacteria modifies their proportions in favour of the ammoniacal form. This form can undergo different transformations during transit (passage from the ammoniacal form to the nitrous then nitric form), particularly in the presence of rainwater rich in oxygen (2 ; 4 ; 10). Its evolution during the treatment can only be carried out from a common basis: the number of moles of nitrogen and/or the masses of nitrogen involved. This is why the loads and concentrations of NH_4^+ , NO_2^- and NO_3^- are expressed in units of N (hence the formula N-N...). The total nitrogen content of the raw effluent varies between 15.22 and 40.90 mg/l. These relatively low averages reflect the dominance of domestic discharge and the weakness of the agri-food industry in the study area.

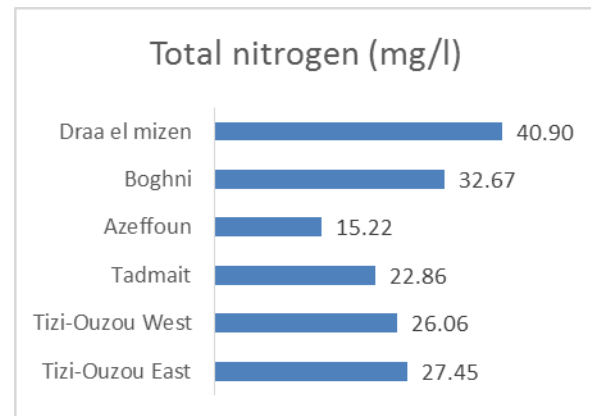


Figure 5. Average nitrogen concentrations in wastewater in the study area (mg/l).

Part of the phosphorus can be eliminated in the sewage system by integrating the sludge formed when the treatment process starts. Phosphorus averages vary between 5.92 and 10.45 mg/l. The recorded values remain below the 50 mg/l direct discharge limit allowed by JORA (2009).

Total phosphorus

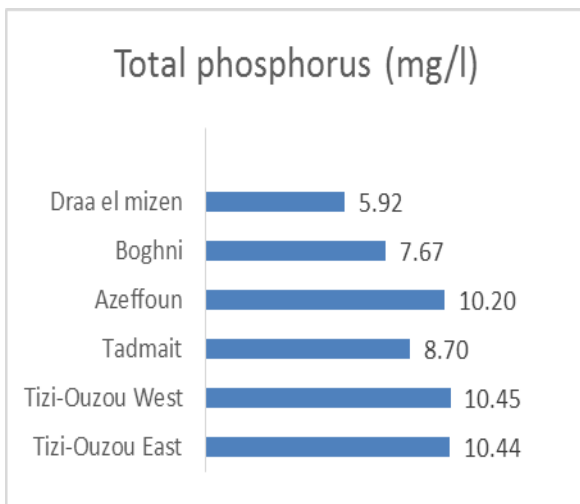


Figure 6. Average total phosphorus concentrations for the study area (mg/l). Calculation of the pollution ratios in population equivalent specific to the study region

For the remainder of the calculations, we considered the actual daily flows in Table 1. These calculations were used to evaluate the

Table 2. Pollution ratios in g/IE/d for the Tizi-Ouzou region

WWTP	MY gMES/IE/d	BOD gO ₂ /IE/d	COD gO ₂ /IE/d	TN gN/IE/d	TP gP/IE/d
Draa El Mizan	25.52	17.68	40.79	4.71	0.71
Boghni	28.06	19.11	47.44	3.9	0.92
Azeffoun	32.21	31.31	52.02	1.83	1.22
Tadmait	26.42	38.85	54.23	2.3	1.04
West Tizi-Ouzou	34.93	53.89	70.75	2.83	1.25
East Tizi-Ouzou	32.99	42.98	57.56	3.29	1.25
Average production per capita per day	30.02	33.97	53.80	3.14	1.07
Reference Ratios	90	60	120	9.9	2

Overall, we note a significant inter-site convergence of daily per capita production values for physical, hydrocarbon, nitrogen and phosphorus pollution. The daily per capita SM production of the wastewater from the different plants varies between 25.52 and 34.93 g/IE/d with an average of 30.02 g/IE/d. This average value is 66.64% lower than the average daily discharge per person of reference, i.e., 90 g/IE/d. The values of the pollution ratio calculated for BOD₅ vary between 17.68 and 53.89 g/IE/d with an average of 33.97 g/IE/d. This calculated average value is also 43.38% lower than the

real daily productivity in the inhabitant equivalent of the urban raw effluent of the study area. The pollution ratio is an important element that characterises wastewater; it gives an idea of the pollution generated by each inhabitant per day (13). The pollution ratio of the different effluents studied is calculated based on the real flows at the WWTP inlet and the global pollution load of the physicochemical parameters measured at the water treatment laboratory of the faculty. The daily production per inhabitant concerning the physical, hydrocarbon, nitrogen and phosphorus pollution per inhabitant and per day, specific for the Wilaya of Tizi-Ouzou, are grouped in Table 2. It is important to note that the reference values recorded in Table 2 are those of DEGREMONT, used during the construction of the East WWTP of Tizi-Ouzou in 2001.

average daily domestic discharge per individual, i.e., 60 g/IE/d. The pollution ratio calculated in terms of COD varies from 40.79 to 70.75 g/IE/d with an average of 53.80 g/IE/d. These calculated values remain 55.17% lower than the reference value of 120 g/IE/d. The estimated daily per capita production of total nitrogen (TN) ranged from 1.83 to 4.71 g/IE/d with an average of 3.14 g/IE/d, 68.28% below the reference value of 9.9 g/IE/d. The daily per capita discharge of total phosphorus (TP) ranges from 0.71 to 1.75 g p.e.d. with an average of 1.07 g p.e.d. This average is 53.50% lower than the assessed reference

value of 2 g/IE/d. As far as the overall ratios are concerned, it can be noted that the calculated values are far lower than the reference values used. The calculated ratios reflect another reality in terms of daily discharges, which would depend directly on the socio-economic models of the connected populations.

CONCLUSION

This study aimed to assess the real daily production per inhabitant in SM, BOD₅, COD, TN and TP at the entrance of the WWTP of the region of Tizi-Ouzou. The results obtained are respectively 30.02 g/IE/d for SM, 66.64% lower than the reference value of 90 g/IE/d, 33.97 g/IE/d for BOD₅, 43.38% lower than the reference value of 60 g/IE/d, 53.80 g/IE/d for COD, which is 55.17% below the reference value, i.e., 120 g/IE/d, 3.14 g/IE/d for TN, i.e., 68.28% below the reference value, which is 9.9 g/IE/d, and 1.07 g/IE/d for TP, which is also 53.50% below the reference value, which is 2 g/IE/d. Comparing the ratios calculated for the study area with the reference ratios shows that the calculated daily productivity values reflect a different reality than the reference values used. This approach would make it possible to optimise the cost, the choice and the dimensioning of the treatment works. Indeed, the results indicate that the daily pollution ratio generated per inhabitant depends closely on the socio-economic models of the connected populations, namely: urbanisation, economic activity, drinking water supply, the type of wastewater collection network and the importance of parasitic water. However, to deepen these conclusions, an exhaustive study of the quality of wastewater per catchment area would be appropriate on the quantitative and qualitative aspects to estimate precisely the quantity of daily pollution generated by each inhabitant.

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