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Study of Physicochemical and Bacteriological Properties of Wastewaters Released Directly into The Natural Environment of Annaba City (North-East Algeria)

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Abstract: The present study was aimed to assess the quality of wastewaters released in different regions of Annaba city (northeast Algeria). The physicochemical and bacteriological parameters (pH, temperature, conductivity, 5-Day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), coliform and faecal loads, faecal streptococci and sulfur-reducing bacteria of wastewaters) released into the natural environment of this city, and their comparison with those applicable in the national legislation have been determined using standard methods. The results showed marked variations in the studied parameters of Annaba wastewaters during the four seasons. The pH, water conductivity, temperature, and COD were increased in seasons, but in winter the conductivity was decreased. Further, the maximum level of total dissolved oxygen (10 mg/l) and suspended matters of wastewaters (1700 mg/l) were observed during winter, since the maximum level of BOD was 515 mg/l, and a lower value (300 mg/l) during winter. The level of minerals (nitrates, nitrites, and phosphorous) was increased in seasons for both waste sites. In addition, the bacterial loads in wastewaters were higher during autumn, spring, and summer than those seen during winter for both waste sites. Consequently, wastewaters released into Annaba natural environment are responsible for serious effects on the health of citizens.

Keywords: Faecal pollution, Wastewater, Collectors, Annaba city

Annaba city is considered a tourist city and one of the largest Algerian cities because its provides all life facilities, including industry, trade, and agriculture. Thus this city is a place of attracting residential and industrial gatherings, charactrized by increased level of which a part is involved in mixed-design wastewater system with equipped mono-type grids (the oldest inherited from the colonial era). Nevertheless, it was observed that the effluents are usually mixed in separated networks, whereas the system includes 13 pumping stations. In the theoretical system, all effluents resulting from wastewaters gather in one site point in the northeast of the city named Sidi Brahim (Sayada et al 2017) and accordingly are drained to the unique station that was created in 2007 and became fully operational in 2010. This station ensures the filtration of the city wastewaters is associated with only 40% of the city wastewater network since the others are in progress of realization. In addition, currently filtrates 10% of the waters coming to it, and as a result, 90% of the untreated wastewaters are released into the natural environment. In recent years, this number has doubled, making it a matter of concern due to its negative impact on the health status of the population inhabiting near valleys, in addition to the spread of water-borne diseases, the disgusting smells, and the inappropriate appearance of the city.

MATERIAL AND METHODS

Study site: This study was conducted on the wastewaters of Annaba city whose area is only 42 kilometer-square, including several watercourses of 34.205 kilometers in length, which are respectively the rivers of Boudjemaa (11,130 Km), Bouhdid (9 Km), SidiHarb (5 Km), Fourcha (5,250 Km) and Kouba (3,825 Km). All these rivers end up to the Boudjemaa river and then to the sea.

Geographical aspect: Annaba city is located in the northeast of Algeria, 600 far from Algiers (capital of Algeria), and faces the sea on a coastline of 80km in length and occupies a part of river estuaries into the Seybouse River, the second river in Algeria and then leans to the huge Edough coast (Fig. 1).

Geomorphological and hydrological aspects: The southern slope basins of Edough are characterized by their proximity to Annaba city at a wide drop that is interspersed with chain of hills, including three distinct areas. The northern plain flowing from Wadi al-Qubbah River and its tributaries. The western plain, which includes the region of Zafaraniya and neighbouring rivers (Farsha, SidiHarb, and BouHadid) and Kharaza plain, located in the southwest part of the city (Wadi Boujmaa Basin).

Importantly, these different and flat lowlands characterized by weak to extremely weak slopes make these parts of the city suitable areas for water stagnation, flooded by strong and steep slopes. Hence, a dense and high-speed hydrographic network with a temporary and abundant inflow on the slopes becomes developed, but it is vulnerable to valley floods flooding large areas with every flood (Fig. 3). Thus, all water drains (Chaabets) are gathered in a one-course direction (Oued Boudjemaa river), where their inflow faces difficulty to reach the natural exit (Sea) between Syebouse and ASMIDAL towns.

The rainwater gathers either directly in the rain channels or trenches, or the pumping stations "Sidi Ibrahim" or "the old station" or "Eliza", which pushes it to the sea and the belt channel. Whereas, all the slopes flow in the direction of the

Fig. 1. Geographical location of Annaba city

Fig. 3. Oued Boudjemaa River is covered by rain waters of the regions: Kharaza, Oued E-Nil, and Saroual (West of Annaba city)

"Kaf Al Nisour" course, heading towards Oued Boujmaa river, and resulting consequently in a large load of sediments and congestion of the main bed river with infrastructures, land dams, and crossing works. Accordingly, the floods were constantly frequent, and from here large areas of water have emerged, including the swamps of the regions; Bosedra, Saroual, Bidari, SidiAshour, and Boukhadra (West of Annaba city). These swamps are mixed with wastewaters, which results in the deterioration of these water bodies, and the spread of unpleasant odors, mosquitoes, and rodents, in addition to distorting the beautiful appearance.

Physiochemical and bacteriological properties: The physicochemical and bacteriological properties of the urban wastewater of Annaba city, which are dumped directly in the natural waterways in the middle of the city for a period of four years (2016-2019) were estimated. The sampling and analysis techniques used in this study are summarized as they are in Table 1.

Study period and location: The study was carried out on two direct wastewater pouring points in natural waterways, selected as two sampling places considering the size of the population and the amount of discharged water. This was for the aim to obtain representative samples in the west of Annaba city ending up in the Mediterranean Sea. Further, the study lasted four years (2016 - 2019) at the same two sites and at the same time set at nine in the morning.

Sampling: The sampling process was performed regularly, twice a month, for the physicochemical characteristics, and monthly for the bacteriological characteristics. The sampling was performed exactly as described by Ort et al (2010). In brief, samples were taken very carefully using sterilized glass bottles of various volumes depending on the type of analysis to avoid any probable contamination and then were kept in a

Table 1. Sampling techniques and analysis of pollution level urban wastewater in Annaba city

Sampling techniques	Analysis of properties
• Sampling points • Method of sampling • The frequency of sampling • Transport of samples	- The daily amount of used water - Heat - pH - Electrical conductivity - Dissolved oxygen - Suspended matters - Nitrite - Nitrates - Phosphorous - Chemical Oxygen Demand (COD) - Biological Oxygen Demand (BOD) - Searching for coliforms and their counts. - Search for fecal coliforms and their counts - Search for Sulfur-reducing Bacteria and their counting

cold place until analysis. Due to the proximity of the two laboratories, the time for transporting samples did not exceed 15 minutes, and so the analyses were performed upon arrival at the laboratory directly.

Techniques for Analyzing Wastewater Properties

On-site measurements: Since some measurements such as temperature, pH, and conductivity of electricity were measured at the site of sampling because it directly interferes with other properties and is affected by the transfer, the measurements are made using a multimeter.

Physicochemical analysis: To show the level of wastewater pollution, the physicochemical properties are analyzed by standardized methods approved in the laboratory at the station level; environmental monitoring of Annaba, affiliated to the National Observatory for the Environment and Sustainable Development (NOESD).

Bacteriological analysis: To show the degree of wastewater pollution, the bacteriological characteristics are analyzed by standardized methods approved by the central laboratory of Annaba city.

Statistical analysis: The presentation of the results of each studied parameter (physicochemical and bacteriological properties) is based on the averages obtained on four independent trays. Pairwise comparisons (physical parameters *vs* threshold control values) were performed with GraphPad Prism (Prism 7, version 7.00, GraphPad Software, California, USA), using the Student's t test with a significance level of 95% as performance reduction.

RESULTS AND DISCUSSION

Temperature and pH: Temperature and acidity are extremely important factors due to their selective role in the micro-bacteria responsible for the decomposition of primary wastes. Therefore, these should be taken into consideration when trying to monitor urban sanitation, and of note, the optimum pH is 5.5-8.0 (Sundberg et al 2004, Zorpas et al 2003). Further, the excessive changes in these two properties in the receiving environment negatively alter the ecosystem as they disrupt and even halt the aquatic and land life.

The temperature of the two downstream water levels was between 11.85 and 21.45 °C and was significantly low for all seasons as compared with what is nationally applicable. This decrease affects the bacterial content growth and the wastewater bacterial activity, contributing to the self-filtering of wastewater (Fig. 5). Moreover downstream pH were between 7.1 and 8.6, indicating a match with what is recommended (Fig. 6) (Taleb et al 2004).

Electrical conductivity: The significant decrease in the conductivity in the winter season compared with the standard is because samples were taken during the days of increased levels of rain-free of mineral salts (Fig. 7). The other seasons revealed a highly significant increase in the conductivity values as explained by the mineralization of the organic matters by the microbial group, along with a slight rise in summer due to the high temperature (a determining factor). Thus, the high conductivity values are explained by the presence of a large number of mineral salts, since these values are significantly below the threshold applicable in Algeria. The specifications of treated wastewater used for irrigation purposes are estimated as 3000µs/cm (Samia 2014).

Aquatic species do not generally tolerate large differences in dissolved salts and this can be observed for example in the case of a wastewater spill (De Villers et al 2005).

Dissolved oxygen content: The dissolved oxygen content was estimated at 5 mg / l under which, the ecosystem begins to suffer, while 2 mg / l indicates that this system has entered the serious hypoxia field (Ménesguen et al 2001).

The value of dissolved oxygen is significantly inferior to

Fig. 4 Annaba city showing the sampling stations

1mg/l (very low value) (Fig. 8) but can cause a great and dangerous impact on ecosystems, leading consequently to suffocation of species organisms found in it. The significant increase in dissolved oxygen in winter compared to that of the threshold control value is because samples were taken in rainy times, and this is obvious because rainwater is rich in dissolved oxygen.

Suspended maters: During four years the urban water discharged was full of suspended matters, which were significantly increased (Fig. 9) than those of the permissible values on the national scale, which subsequently causes concern, especially in the case when the suspended matters cause the formation of sludge and drain clogging and the proliferation of anaerobic bacteria leading to the emission of bad odors and pathogens. The suspended matters are significantly higher in winter as compared to that in the other seasons and the control limit values. This is due to the mixing of wastewaters with rainwater, which cleans roads and rooftops, bringing with it dirt and dust.

Nitrite: The urban wastewater is a significant source of nitrite and that its high levels negatively affect the ecosystem (Fig. 10). The excess nutrients from wastewater dumping make their way through watercourses into surface and underground ecosystems located below the hydrographic network. The the equilibrium of aquatic ecosystems can be disrupted by altering the inherent physical, chemical, and biological properties of waterways (Chrétien et al 2017), which consequently leads to the excessive growth of algae resulting in the impoverishment of dissolved oxygen.

Nitrates: Alike to nitrite, nitrates are a source of nitrogen and thus, promoting enriching surface and ground aquatic environments. The high level of nitrates badly affects public health, especially for children (new-borns). Most scientific studies have reported an increase in algal blooms over the past 30 years. In addition, the nutrient richness of water in some French coasts (mainly N and P) via anthropogenic discharges would explain the observed increase in algal blooms, and possibly the evolution of toxic species (Chrétien et al 2017).

Phosphorous: In the phosphorus level in two contaminated wastewater sites in Annaba city increases proportionally and significantly during the four seasons of the study period as compared with the normal reference values (Fig. 12). Additionally, this increase is high in summer because of the intensified use of detergents during this hot season, and consequently, this indicator must be taken into account in the filtering of wastewaters. Phosphorus is naturally present in very small quantities in soil, water, and in the bodies of biological organisms. A high concentration of phosphates can lead to algal blooms when becomes a nutrient for plants.

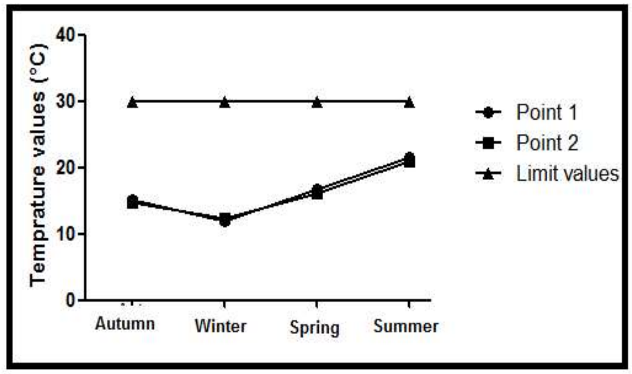

Fig. 5. Variation of temperature during the four seasons of the study period

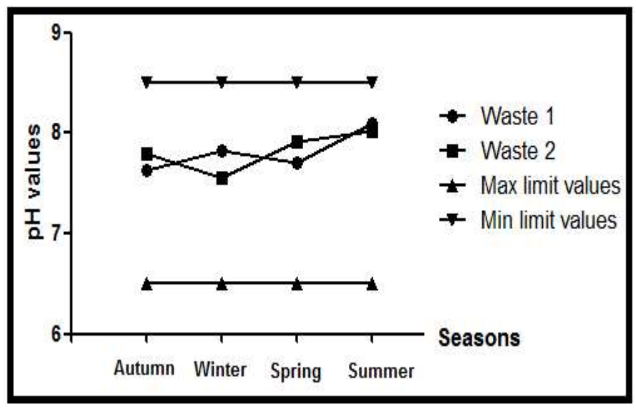

Fig. 6. Variation of pH during the four seasons

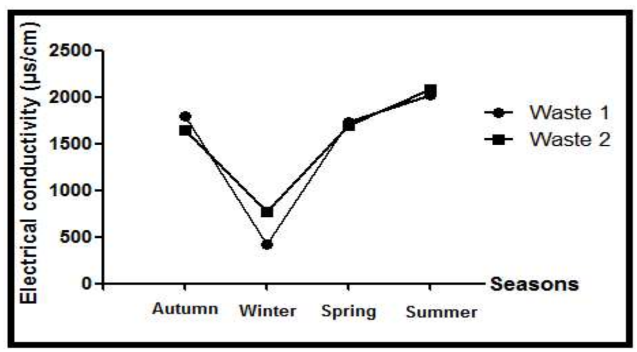

Fig. 7. Variation of electrical conductivity during the four seasons of the study period

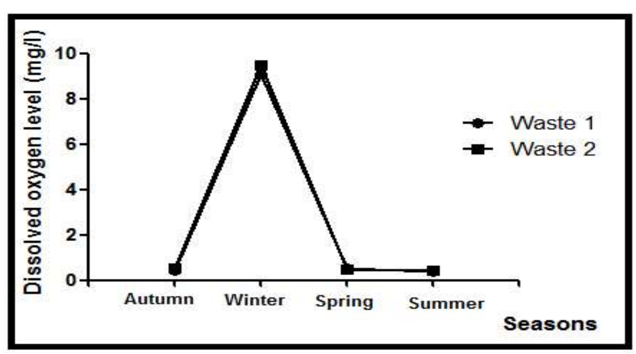

Fig. 8. Variation of dissolved oxygen content during the four seasons

Algae are responsible for the eutrophication of stagnant waters. This process is more or less important depending on the phosphate content in the wastewater. The phosphorus is the limiting factor involved effectively in reducing eutrophication (Donnert and Salecker 1999).

Biochemical oxygen demand (BOD5): The biochemical oxygen demand is an indication of the amount of biodegradable organic matter in the water and is related to the amount of oxygen consumed by the microorganisms in the demolition of dissolved and suspended organic matters. The significant increase in BOD5 values, ranging from 300 to 480 mg / l was observed (Fig. 13) and this is known as a characteristic of the urban wastewater in the natural state due to its containing a huge amount of aerobic microorganisms in addition to dissolved and suspended organic matter. This leads to a state of suffocation and rotting in the natural environment receiving a lack of dissolved oxygen consumed by aerobic microorganisms (Graham 2011).

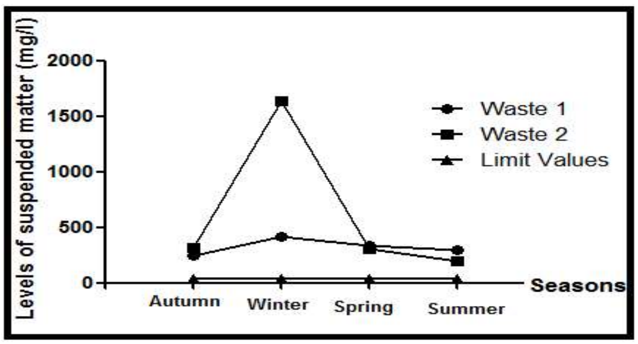

Fig. 9. Variation of suspended matter level during the four seasons

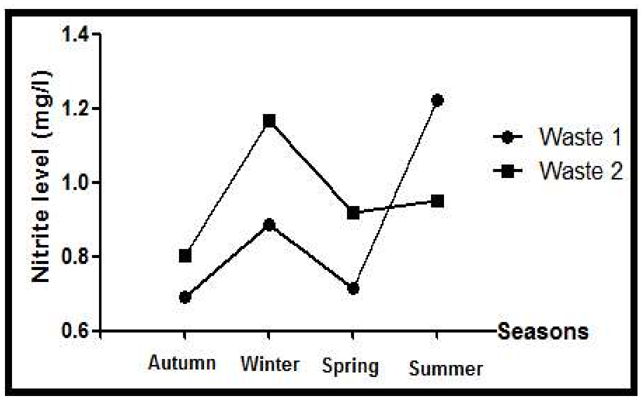

Fig. 10. Variation of nitrite level during the four seasons

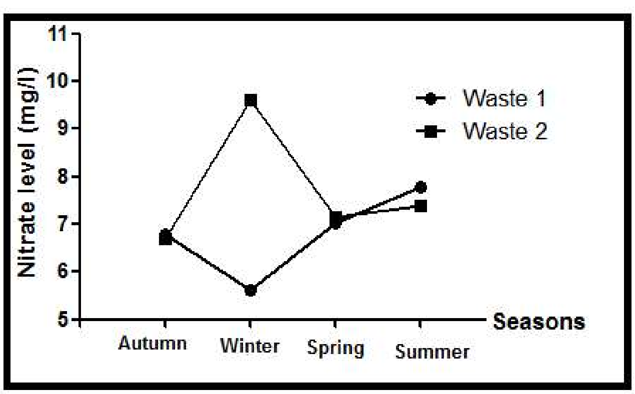

Fig. 11. Variation of nitrate level during the four seasons

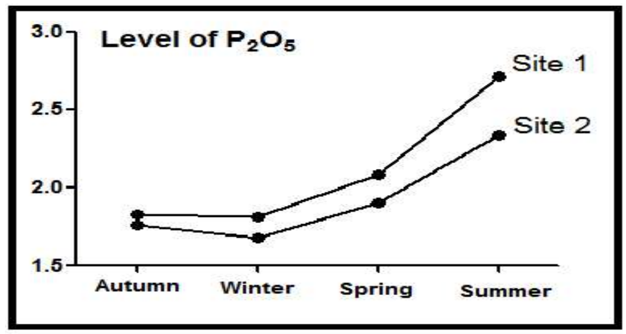

Fig. 12. Variation of phosphorous (P_2O_5) level during the four seasons

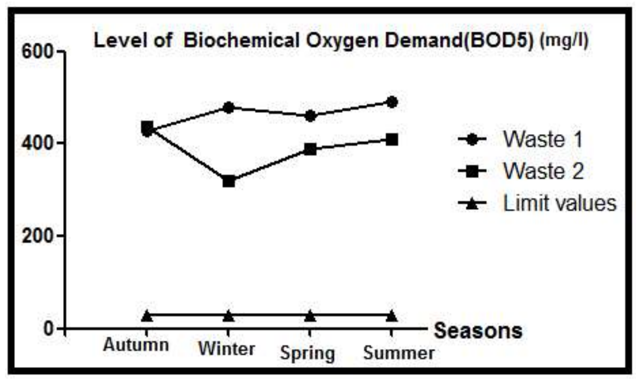

Fig. 13. Variation of levels of biochemical oxygen demand (BOD5) during the four seasons

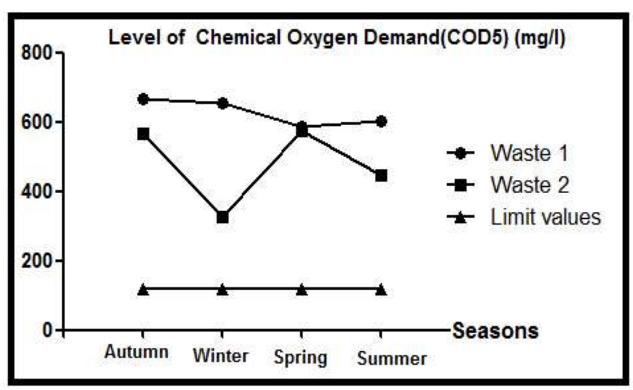

Fig. 14. Variation of levels of chemical oxygen demand (COD) during the four seasons

DCO/DBO = 1,36 Point 01 Well-degradable organic load
DCO/DBO = 1,22 Point 02
In accordance with Mougeot (1999), the rapport DCO/DBO5 indicates that the waters are perfectly biodegradable

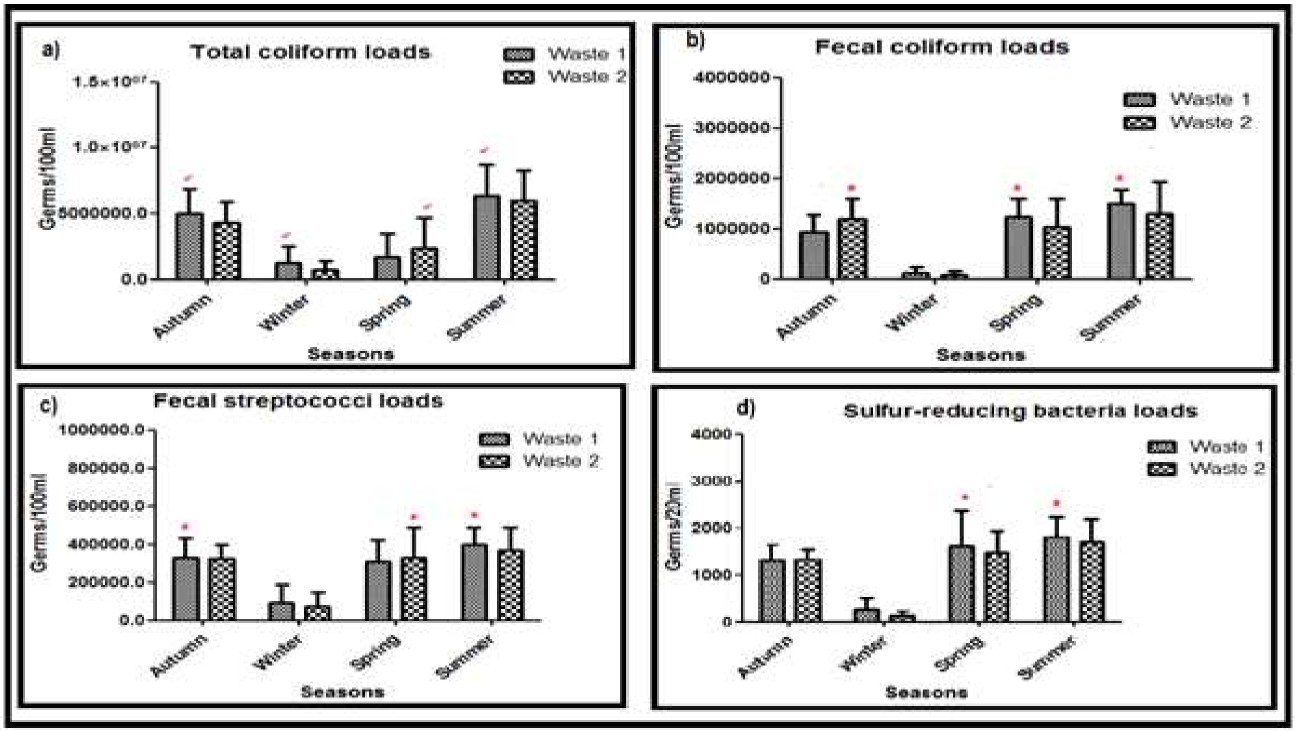

Fig. 15. Bacteriological evaluation of wastewaters of Annaba city: a) total coliform loads; b) faecal coliform loads, c) faecal streptococci loads, d) sulfur-reducing bacteria loads

Chemical oxygen demand (COD): There was significant increase in the chemical oxygen demand values is shown, ranging from 450 to 680 mg /l is due to the high content of oxidants, whether organic or mineral, in the wastewater (Fig. 14).

Bacteriological parameters: The total coliforms colonize the digestive tract of humans and animals and control the recent faecal contamination. There was significant increase in the number of coliform bacteria (up than 10^7 /100ml) (Fig. 15a) refers to the degree of risk of contamination with pathogenic bacteria**.** The enumeration of faecal coliforms revealed a relatively high rate of these microorganisms, averaging over 10^6 germs / 100 ml of sample **(**Fig. 15b**).** Furthermore, **t**he saprophytic streptococci group D, common of the nasopharyngeal and intestinal tracts of humans and animals, were chosen as indicators of older faecal pollution, due to their greater persistence in the environment**.** In addition, the counting carried out on raw water revealed a relatively low density of these bacteria compared to that of faecal coliforms and was estimated to be around 10^5 germs / 100 ml. The pathogenic organisms in wastewater can transmit diseases. Additionally, faecal Streptococci are proposed as indicators to confirm pathogen reduction efficiency, and noteworthy, faecal Streptococci are the only indicators exhibiting a significant correlation with listeria monocytogens. These would also be reliable indicators, in particular for evaluating the reduction of Salmonella (Fig. 15c). The sulphur reducing bacteria, require a strict absence of oxygen**.** The spore form can provide a good understanding of any contamination, recent or previous, although the new European directives no longer consider them as faecal pollution indicators. There was significant increase in sulfur-reducing bacteria rate responsible for the emission of foul smells than that of threshold control (Fig. 15d).

CONCLUSIONS

The large percentage of wastewaters pollution in the city evidenced by the increased levels of pH, water temperature, conductivity, suspended matter, nitrogenous and phosphorous materials. The water dissolved oxygen was decreased during seasons, except winter where the oxygen level reaches its maximum of 10mg/l. Moreover, the results showed high levels of coliform bacteria (more than 10^7 in 100 ml), streptococcus protozoan, and sulfur-reducing bacteria, which exceeded the permissible values on the national scale. This results in a negative impact on public health through the emission of disgusting odors. Therefore, there is no doubt that these dangerous results lead us to seriously think about the consequences that wastewater can leave behind, and hence to search for mechanisms and means to be taken to eliminate, or at least to reduce the harmful impact of wastewater.

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