Assessment of the environmental impact of urban wastewater and the treatment capacity of the Saida activated sludge plant (North-western Algeria) on the occasion of Eid Al-Adha

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https://doi.org/10.5937/vojtehg73-55420

FIELD: chemical technology, environmental science
ARTICLE TYPE: original scientific paper

Abstract:

Introduction/purpose: The slaughter of livestock during Eid Al-Adha generates significant quantities of wastewater rich in organic pollutants. However, the specific impact of these effluents on water quality remains poorly documented. This study aimed to assess the pollutant loads discharged into the Saida Valley during Eid Al-Adha and evaluate the treatment capacity of the local activated sludge wastewater treatment plant (WWTP).

Methods: Water samples were collected from different points in the sewerage system at various times throughout the day during three Eid Al-

Adha events (2017, 2018, and 2019). Several physico-chemical parameters were analyzed, including temperature, pH, electrical conductivity, chemical oxygen demand (COD), five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), ammonium, nitrates, nitrites, and phosphorus. The measured pollution levels were compared to the Algerian regulatory standards to assess compliance.

Results: The analyses revealed a sharp increase in pollution levels in the morning, followed by a gradual decline in the evening. High pollutant loads from slaughter effluents significantly degraded the water quality of the Saïda River. The organic pollution index classified these discharges as very high pollution. The excessive input of organic matter and nutrients resulted in oxygen depletion and eutrophication risks.

Conclusion: The discharge of untreated slaughter wastewater poses serious environmental and public health risks. Strengthening wastewater management strategies during Eid Al-Adha, enhancing treatment processes at the Saïda WWTP, and enforcing strict environmental regulations are essential to mitigating these impacts.

Key words: Eid Al-Adha, activated sludge WWTP, biodegradability, pollutant load, receiving environment, wastewater.

Introduction

The protection of the environment is an objective in policies of most countries in terms of preserving natural resources and ecosystems, as well as protecting public health (Chennaoui, 2003). In this context, wastewater, excreta, and greywater could be considered costly by-products of the urbanization process, requiring significant investments in treatment plants and disposal mechanisms (Asibor et al, 2020). Freshwater resources are being depleted at an alarming rate due to increasing water consumption. Consequently, the volume of wastewater discharges increases considerably (Bhave et al, 2020). In recent years, the scarcity of fresh water and the treatment of wastewater are among the main environmental challenges (MWR 2017). Algeria ranks 29th among the countries most vulnerable to water stress. It is thus classified in the category of “high” water stress, the second largest category behind that of “extremely high” water stress. The anchoring of Algeria in the path of sustainable development has prompted the public authorities to resume the policy of sanitation and wastewater treatment. Thus, a special fund has been set up to support the management and recovery of treated wastewater. It is a pioneer on the African scale in the construction of wastewater treatment plants. A number of 172 stations operate throughout the national territory, providing approximately one billion cubic meters of treated water for agricultural irrigation (MWR 2019). Hydrous environments and aquatic ecosystems must be protected against all forms of pollution likely to alter water quality and harm its various uses (JORA, 2003). Thus, uncontrolled wastewater discharges, loaded with organic matter and mixed with chemicals, are therefore a fundamental element in terms of pollution because they are the site of many chemical reactions and the reproduction of many disease vectors (De Anda et al, 2018; Gautam et al, 2013). This uncontrolled disposal of untreated sewage is the main cause of water contamination which causes waterborne diseases such as cholera, typhoid, and infectious hepatitis. This leads to a high risk of disease transmission due to the presence of pathogens in irrigation water (Kokkinos et al, 2015).

In August 2018, the Ministry of Health and Population revealed contamination of water by the "cholera vibrio" virus, which was the main cause of the spread of a virulent infection, resulting in two deaths in the central regions (Algiers, Blida, Tipasa and Bouira) two days after the 2018 Eid holiday. The return of cholera, which last appeared in 1996, reminds Algerians of certain bitter truths. It reveals major dysfunctions. This is due to the evacuation of effluents on the day of Eid Al-Adha into the receiving environment without any prior treatment and to the use of this water for the irrigation of vegetables and fruits (melon, watermelon, tomato, salad, etc.). The U.S. Environmental Protection Agency has ranked slaughterhouse discharges (Identical to Eid Day sacrifice discharges) among the most environmentally damaging (Walter et al, 1974). Raw water quality assessment and treatment at the station inlet are widely preferred (Bayo & López-Castellanos, 2016).

Muslims around the world celebrate the occasion of Eid Al-Adha which marks the end of the period of pilgrimage to Mecca. All the slaughtering, skinning and evisceration operations are carried out in the same place. From a symbolic viewpoint, this celebration is "the feast of sacrifice", translated in Algeria, by the slaughter of an average of 4 million animals (sheep, cattle, goats or camelids). Domestic drinking water consumption peaks on the first day of Eid, the average daily quantity of 9 million cubic meters of water distributed nationally is consumed within 6 hours, thus generating an average of 7.5 million cubic meters of waste water. For the capital of Saida region, average production is 1300 tons of slaughtered carcasses (producing approximately an average of 710 tons of waste/day and an average of 10608.39 m^3/day of wastewater, an average of 8 liters per kg of carcass. The operator of the Saida wastewater treatment plant bypasses the wastewater discharges today directly into the Saida river without any treatment on the pretext that such events cause a significant accumulation of mineral sludge in the structures, which would further delay the resumption of normal operation of the plant. Moreover, the pollution load of these waters exceeds the capacity of the plant; this would create various problems of fouling of the structures and organs operation of the installation (NHO, 2017).

The present study consists, initially, of monitoring certain major pollution parameters generated by the discharge of wastewater on this occasion and then estimating the polluting loads brought. Finally, the impact of discharges on this occasion on the purification capacity of the Saida station was assessed.

Materials and methods

Study area

The city of Saida is located in northwestern Algeria (Figure 1), it covers an area of 6 613 km^2. In this region, conventional water resources are mainly underground. Water availability is around 230 m^3/inhabitant/year (ratio of 47% of the national average). The city is 98% connected to the sanitation network. All of this wastewater drained by the districts of the city is directed to the treatment plant.

Figure 1 – Location of the study area

The Saida region wastewater treatment plant is located in the northwestern part of the city. It is located near the Saida River in the municipality of Rebahia. This station covers an area of 11.47 ha. It is designed by the Spanish company (SACOM DIESA Algeria sector) to treat a nominal flow rate of waste water of 30 000 m^3/day with a capacity of 150 000 equivalents/inhabitant.

The collection system connected to the treatment plant is unitary. The pollution that the station receives comes from urban domestic discharges and certain industrial discharges. As shown in Figure 2, the main collectors of the station are A, B, and C. The culmination of the collectors A and C is done by gravity. Wastewater from the collector B is routed to the pumping station and then crosses the river to reach the collector A.

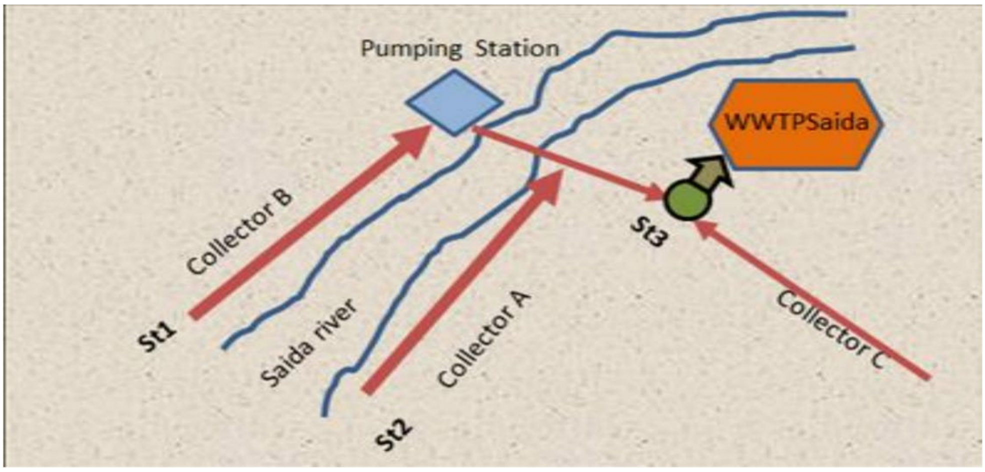


Figure 2 – Main sewers of the Saida sewerage network

The Saida wastewater treatment plant operates with a low-load activated sludge process. It has two parallel biological treatment lines. Each line is composed of a biological reactor followed by a clarifier. The biological reactor is the first link in secondary treatment.

The station's two basins are rectangular with a total volume of 13 068 m^3 for each basin. Mixing and oxygenation are ensured by six vertical axis surface aerators having a total nominal power of 900 kw, total oxygen supply of 1296 kg O_2/h and a specific mixing power of 34.4 w/m^3.

It also has two parallel cylindrical-conical settling tanks, equipped with a scraper and a suction bridge and two sludge extraction pumps, with a volume of 5800 m^3 for each basin, a horizontal surface of 1452 m^2 and a peripheral height of 3 m (Figure 3).

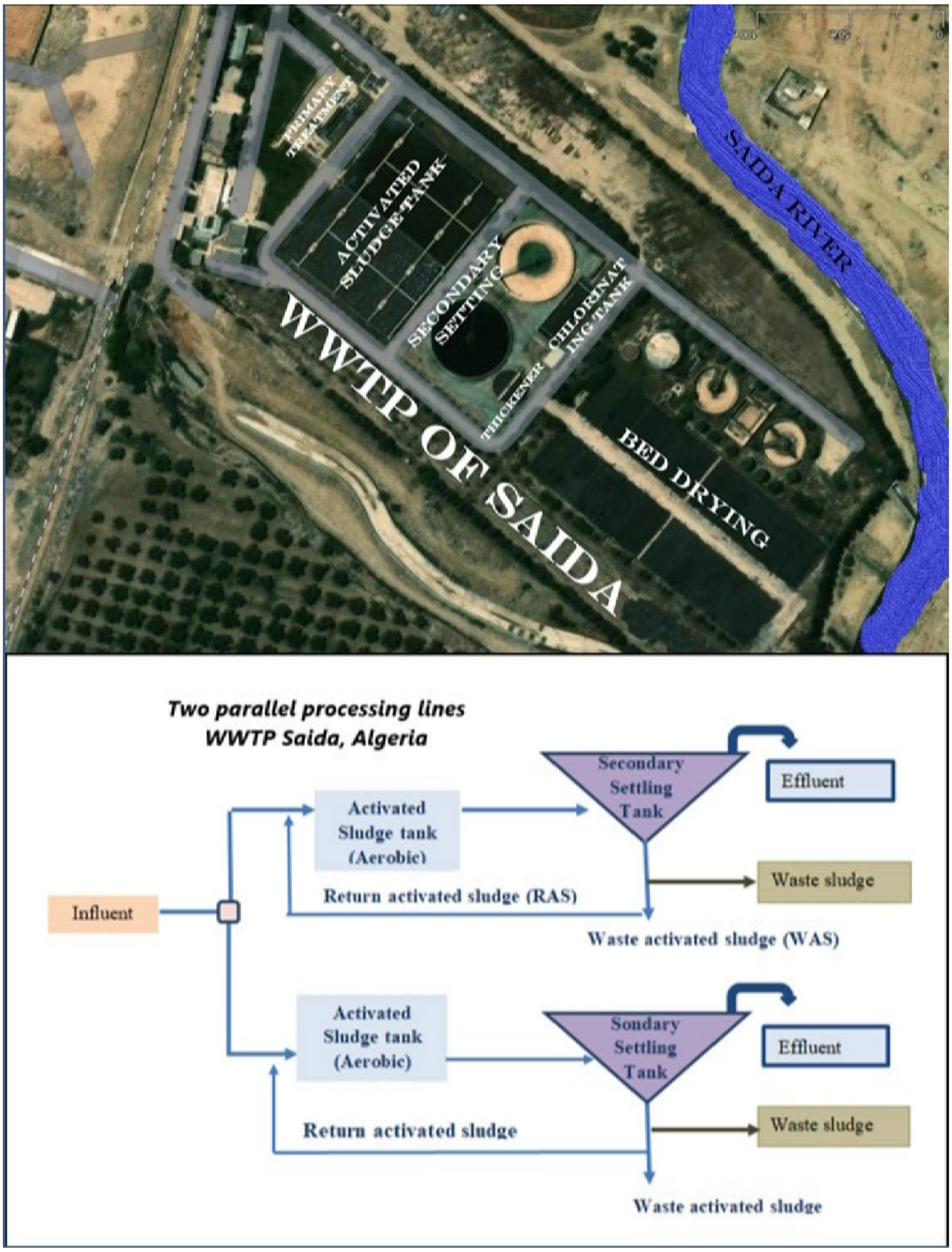


Figure 3 – Schematic presentation of the biological treatment of the Saida WWTP

The technical characteristics of the station are summarized in Table 1.

Table 1 – Technical characteristics of the Saida WWTP (NHO, 2017)

Type of sewerage network.	unit	
Average daily flow	30 000 m^3 /d	
Daily load in BOD5	9 000 kg/d	
Daily load in TSS	12 000 kg/d	
Purification objective	Inlet (mg/l)	Outlet (mg/l)
BOD5Concentration	300	30
TSS Concentration	400	30
COD Concentration	/	120
Concentration of NH4+	/	5

Sampling and physical-chemical analysis

During the occasion of Eid Al-Adha, all wastewater is directed to the receiving environment (Saida River) without any treatment. Three sampling points (St_1, St_2, and St_3) were identified (Figure 4).

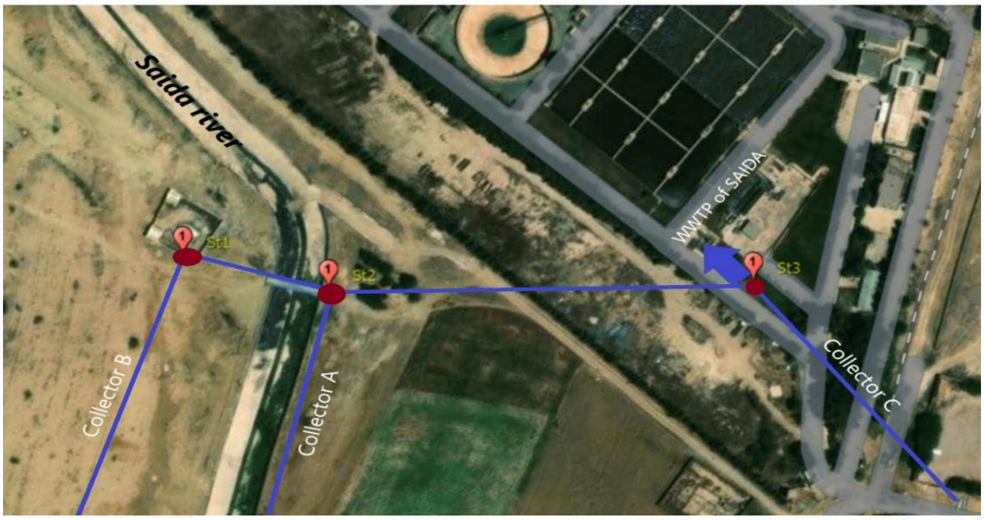


Figure 4 – Locations of the sampling sites

The samples were taken on the day of Eid Al-Adha on three consecutive occasions - August 31, 2017, August 20, 2018, and August 10, 2019. The geographical location of the three sampling sites is given in Table 2.

Table 2 – Details of the sampling locations

N°	Location name	Coordinates	Description
1	St1	N34°52'18.7783" E0°08'39.2476"	B upper part manifold of the Saida city
2	St2	N34°52'18.2713" E0°08'41.7581"	A collector of the lower part of the Saida city
3	St3	N34°52'18.3980" E0°08'49.0967"	Upstream of the WWTP

Wastewater samples were collected using a wide-mouth container. The container is placed on a stick to fill a 3-liter bucket. The bucket used is made of plastic material free of pollutants and preservatives. The bucket was rinsed with wastewater for sampling. Samples are taken a few centimeters below the water surface without approaching the bottom. Then, the samples were covered and labeled with their origin and time of collection. The samples were stored and transported in a cooler at a temperature close to 4°C.

The monitoring of physical-chemical parameters was carried out with a frequency of one sample every half hour in the time intervals from 08h:00 to 20h:00.

In the present study, the physical-chemical parameters analyzed are temperature, pH, electrical conductivity, dissolved oxygen, five-day biological oxygen demand (BOD_5), chemical oxygen demand (COD), suspended matter (TSS), and the concentration of ammonium, nitrite, nitrate and total phosphorus (Pt). All the tests are carried out in the ONA laboratory at the Saida STEP, according to the methods described in the ISO standard (ISO, 2025). Temperature, pH and electrical conductivity measurements were taken "in situ".

Table 3 shows the different parameters measured. The analytical methods used are based on the principles of the NF-EN-ISO standards while respecting the required quality assurance/control rules.

Table 3 – Principles of measurement of the different parameters studied (Rodier, 1975)

Parameter	Abbreviation	Standards
Suspended matter	TSS	NF T90-105
Biochemical oxygen demand	BOD_5	NF T90-103
Chemical oxygen demand	COD	NF T90-101
Nitrates	NO3-	NF T90-012
Nitrites	NO2-	NF T90-013
Ammonium	NH4+	NF T90-015
Total phosphorus	Pt	NF T90-023
Conductivity	Cond	NFT90-31

Temperature, pH, and electrical conductivity are measured using a thermometer (Checktemp Dip - HI98539), a conductivity meter (HACH HQ 1110,) and a pH meter (HACH HQ 1110, IP67), respectively. For suspended solids, the analysis is based on filtration and drying at 105°C for 2 hours. The BOD_5, using a BOD-meter (OXITOP112), was determined. The COD was measured with a mineralization station (Hach, DRB 200). For the measurement of nitrate, ammonium, nitrite, and phosphorus content, a digestion block (BUCHI Speed Digester K-436) and a distillation unit (BUCHI K-350) were used. The results were read with a spectrophotometer.

Pollution indices

The calculation of the Organic Pollution Index (IPO) is based on the distribution of the values of the polluting elements into 5 classes (Table 4). Then, the class number is determined according to its measurements BOD_5 (mg O_2/l)), ammonium (mg N/l), nitrite (µg N/l), phosphate (µg P/l) and finally used to achieve the mean (Table 5).

The calculation principle of the Lisec-index is the same as the IPO index, but replacing the average of the classes by the sum of the classes. The principle of calculation of the Index of the Institute of Hygiene and Epidemiology IHE is the same as the IPO, but with other classes and other parameters (dissolved oxygen %, COD (mg O_2/l), BOD_5 (mg O_2/l), Ammonium (mg N/l), Phosphate (µg P/l), and Phosphorus (µg P/l)).

Table 4 – Class limits of the organic pollution index (Al-Hejuje et al, 2017)

Parameters / Classes	BOD5 (mg/l)	NH4+ (mg/l)	NO2- (µg/l)	PO4- (µg/l)
5	< 2	< 0.1	5	15
4	2 - 5	0.1 – 0.9	6 - 10	16 - 75
3	5.1 - 10	1 – 2.4	11 - 50	76 - 250
2	10.1 - 15	2.5 – 6.0	51 - 150	251 - 900
1	>15	>6	>150	>900

OPI = Average class number of 4 parameters

Table 5 – OPI classes, pollution degrees

Classes average	Organic pollution level
5.0 – 4.6	Null
4.5 - 4.0	Low
3.9 – 3.0	Moderate
2.9 – 2.0	High
1.9 – 1.0	Very high

Results and discussion

Flow estimation

The increase in population, as well as in water consumption, leads to an increase in the production of wastewater. In Table 1, the average flow of collected wastewater is calculated taking into account the increase in population corresponding to the sanitation master plans. The average flow treated is measured at the entrance to the treatment plant. The average flow discharged into the receiving medium without treatment is the difference between the two flow rates collected and measured. Eid Al-Adha’s occasional wastewater flow is calculated by multiplying the number of carcasses slaughtered by the average volume used per carcass (8 l/carcass). The average flow of water discharged without treatment on the day of Eid Al-Adha is the sum between the average flow discharged into the receiving environment without treatment and the occasional discharge of Eid Al-Adha.

More than 98% of homes are connected to sewers. In 2017, only 72% of waste collected was treated without danger. The 28% untreated present risks to the environment and public health. The results show that the rate of water discharged without treatment into the receiving environment decreases from 27% in 2018 to 23% for 2019 (Table 6).

Table 6 – Monitoring of wastewater in the city of Saida

Wastewater rate	Values (m3/d)		
	2017	2018	2019
Average flow rate of collected wastewater	28679.8	28812.9	29537.8
Average flow rate treated in the WWTP	19110	21050.4	22644.1
Average flow rate released into the receiving environment without treatment	9569.8	7762.5	6893.7
Percentage of connection to the WWTP	33%	27%	23%
Occasional flow of wastewater on Eid Al-Adha without treatment	10474.58	10447.74	10902.86
Average flow of water discharged without treatment on the day of Eid Al-Adha	20044.38	18210.24	17796.56

This shows the interest that local authorities attach to the collection of wastewater discharges. During Eid, all wastewater is directed to the receiving environment (Saida River) without any treatment .

Influent flow

The analysis of the curve shape in Figure 5a shows a variation in the flow of wastewater throughout the day of sacrifice. The average rejection on that day did not change much for the three occasions. It varies between 10 447.73 m^3/d and 10 902.86 m^3/d. The volume of wastewater varies significantly. It is related to the number of slaughtered animals and the nature of the slaughtered animals.

The volume of wastewater increases in the morning from 9 a.m. until noon. The examination of the daily variation reveals the presence of three peaks which appear around 10 a.m., 11 a.m., and 2 p.m. The peaks of 10 a.m. and 11 a.m. are due to the use of water for cleaning after slaughter. It decreases during the lunch hour, between noon and 1:00 p.m. The peak at 2:00 p.m. is due to water consumption linked to the lunch break, which lasts from 30 min to 2 h. The average total discharge of urban wastewater on the days of Eid on the three occasions (2017, 2018, and 2019) varies from 39 154.32 to 40 440.66 m^3/d with an average of 39 618.54 m^3/d (Figure 5b).

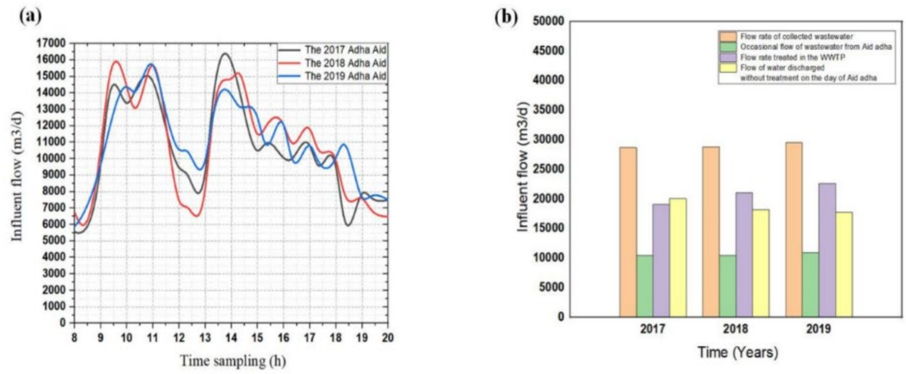


Figure 5 – (a) Variation of waste water from the slaughter on the day of the sacrifice. (b) Variation in the average daily flow of urban wastewater from Saida on Eid day

This average flow is higher than the regulatory dry weather capacity of the treatment plant, which is 30 000 m^3/d. It is influenced by the mode of use of drinking water which is inevitably accompanied by increasing production of polluting discharges.

Physical-chemical characteristics of the Eid effluents

These effluents have a reddish appearance, an unpleasant odor and are heavily loaded with figurative elements, trimming debris, blood clots, pieces of horns and claws, stomach contents, feces, straw, and possibly other organic constituents. They are drained through the collectors towards the Saida river without treatment. Table 7 gives the average of the results of the physical-chemical parameters of the effluents of the three sampling stations for three Eid occasions. The bacteriological analysis of the discharges will be the subject of another work.

Table 7 – Average of the parameters on the day of sacrifice

	Year 2017	Year 2018	Year 2019	Threshold values
Temperature(°c)	24.0	23.5	22.5	25
pH	7.7	7.7	7.5	6.5 - 8.5
Cond (µs/ cm)	1406.7	1377.5	1487.9	2700
TSS (mg/l)	866.9	668.0	686.2	40
BOD5 (mg/l)	485.6	397.0	387.9	40
COD (mg/l)	740.8	741.9	687.8	130
NO3- (mg/l)	54.0	64.6	65.1	50
NO2- (mg/l)	1.8	2.5	1.8	< 01
NH4+ (mg/l)	126.1	108.1	117.9	< 02
Pt (mg/l)	23.3	33.9	22.4	< 02
Cl- (mg/l)	567.6	547.5	650.5	/
COD/BOD5	1.5	1.9	1.8	/

Temperature and hydrogen potential

The results show that the water temperature values fluctuate between 23°C and 24°C limit values for direct discharge into the receiving environment (JORA, 2006). For the three occasions, the samples taken show high temperatures from 9:00 a.m. until 6:00 p.m. This is due to the influence of air temperature over 45°C in August and the usage of hot water for grease cleaning (Figure 6).

The pH is an important parameter that represents the degree of ionization of the studied medium. It gives an indication of the level of water pollution. It should be closely monitored during sampling. The analysis of the pH evolution of the water shows that the average pH values recorded for the different stations studied and on the three Eid occasions are relatively similar. These values range from 7.65 to 7.66 (Figure 7). It is within the acceptable range for wastewater discharge which is between 6.5 and 8.5 according to the Algerian regulations. The values obtained are comparable with those of other places of slaughterhouse wastewater, which generally have a neutral to slightly basic pH (Belghyti et al. 2009).

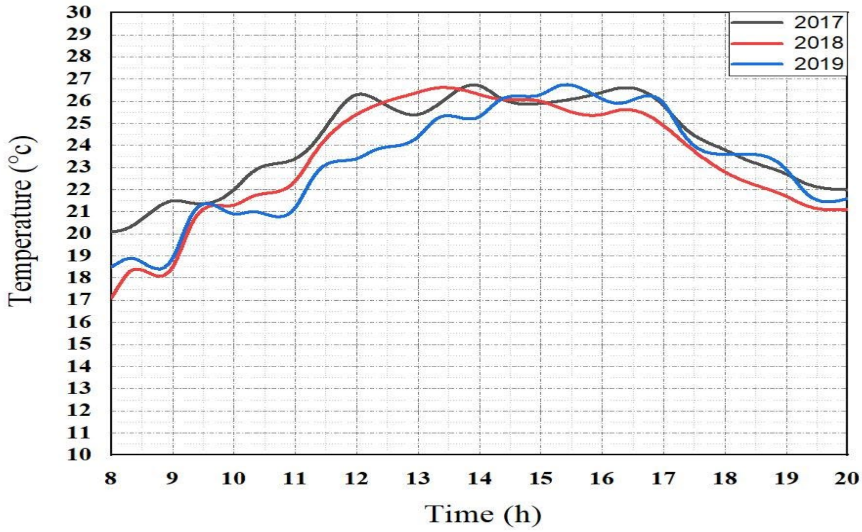


Figure 6 – Temperature for the three occasions of Eid

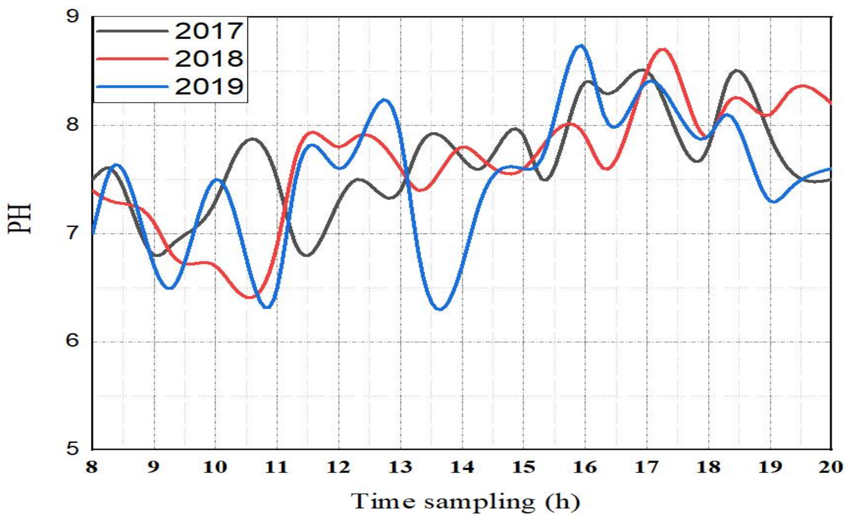


Figure 7 – PH for the three occasions of Eid

Conductivity and chlorine

The electrical conductivity of water reflects its ability to allow an electric current to pass. This ability is due to the presence of ions in the water, which transport the charges. Therefore, higher mineralization of water increases its conductivity. Conductivity measurement is thus a quick and effective way to assess water mineralization (Rodier, 1975).

Any polluted discharge typically leads to an increase in conductivity (Rejsek, 2002). The observed results, ranging from 1377.44 µs/cm to 1487.9 µs/cm, indicate significant variance in mineralization as reflected in the average conductivity. This can be attributed to the discharge of highly mineralized wastewater. These values comply with the Algerian standards for wastewater discharge into natural environments, such as surface or groundwater, which require conductivity to be ≤ 2700 µs/cm.

After the slaughtering of the Eid sacrifices, the chlorine values range between 547.55 mg/l and 650.52 mg/l. The use of bleach for cleaning is the main reason for the high chlorine concentration. These results can be explained, on the other hand, by the formation of wastewater discharge rich in minerals rich in fertilizers and nutrients (N.C.P).

From Figure 8a, there is a clear association between variations in conductivity and chlorine concentrations. The variation in conductivity follows the variation in chlorine concentration for the three Eid occasions (Figure 8b). Chlorine contributes to high discharge conductivity.

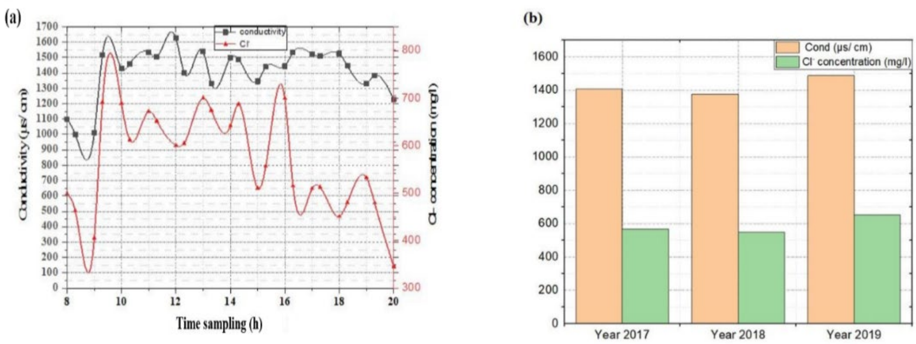


Figure 8 – (a) Variations in conductivity and chlorine concentrations after slaughtering (b) Conductivity and Cl - concentration for the three occasions of Eid

A good statistically significant correlation is observed between conductivity and chlorine (R^2=0.41) (Figure 9).

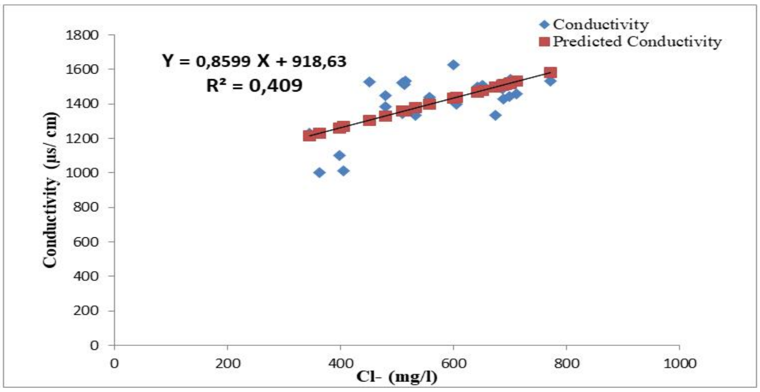


Figure 9 – Correlation between conductivity and chlorine of waste water on the day of Eid Al-Adha

Ammonium, nitrates and nitrites

Ammonium, nitrates, and nitrites are all types of nitrogen compounds. These variables were included because they have an impact on the eutrophication process. Proteins, polypeptides, amino acids, and urea are the principal sources of nitrogen organic. The majority of total nitrogen is mineral nitrogen, which contains ammonium ($NH4^+$), nitrite ($NO2^-$), and nitrates ($NO3^-$). The released effluent had extremely high levels of ammonium and nitrate, with average concentrations of 117.41 mg/l and 61.26 mg/l, respectively (Figure 10a).

The comparison of the average concentrations of ammonium and nitrate in the wastewater analyzed with the discharge threshold values shows that these concentrations vary respectively from 54.03 m/l to 65.12 mg/l, which makes it possible to conclude that these effluents represent a high pollution load in terms of pollution of the receiving environment by nitrogen. These rates are almost identical for the three years studied due to the particular nature of the releases on this occasion (blood and debris). One liter of blood provides 25 grams of NTK (Peiffer, 2002). For nitrites, which constitute an important step in the metabolization of nitrogen compounds, it is a transitional phase between ammonium and nitrates. Nitrites generally come either from an incomplete degradation of ammonia or from a reduction of nitrates.

The low concentrations of nitrites, average 2.01 mg/l encountered in the wastewater from the effluent studied (Figure 10a) are explained by the fact that the nitrite ion ($NO2^-$) is an intermediate compound, unstable in the presence of oxygen, and generally has a lower concentration of both forms, nitrate and ammonium ions.

A statistically significant correlation is observed with conductivity (R^2 = 0.4) (Figure 10b).

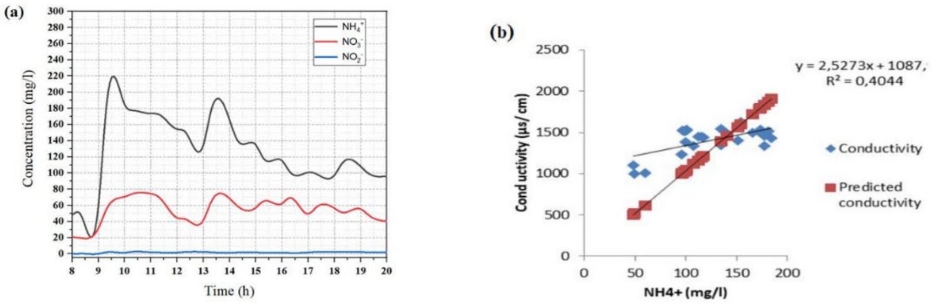


Figure 10 – (a) Evolution of the nitrogen pollution for the three occasions of Eid. (b) Statistically significant correlation is observed with conductivity (R2 = 0.4)

Total phosphorus

Phosphorus compounds exist in natural waters and wastewater in different forms, namely soluble orthophosphates, water-soluble phosphates, and organophosphate derivatives. The average total phosphorus value of 26.52 mg/l is well above the limit value of 2 mg/l (Figure 11). This content is due to the nature of the wastewater (urine and animal faces), and to the use of detergents for cleaning. Indeed, many detergents contain phosphates; the sodium tripolyphosphate (STPP) content of some detergents can exceed 50%.

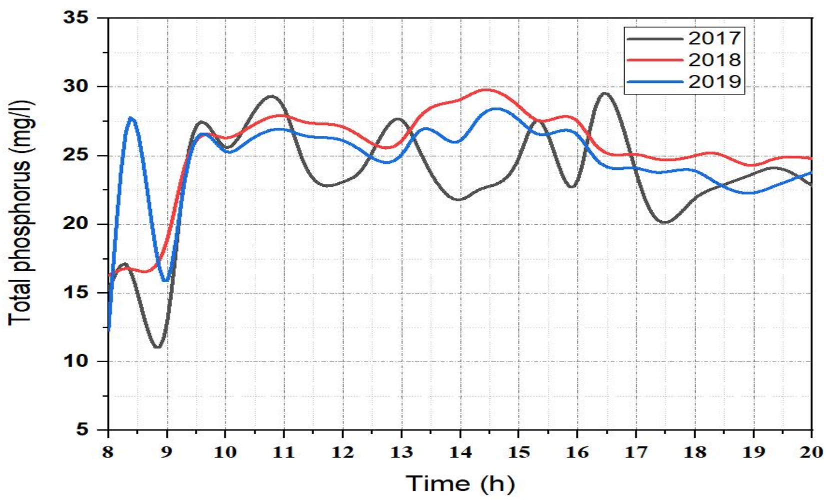


Figure 11 – Evolution of the total phosphorus

Suspended matter

TSS represent all the mineral and organic particles contained in water. They depend on the nature of their releases. In general, TSS are involved in the composition of water through their effect of ion exchange or absorption on both trace chemical elements and microorganisms. Variations of this parameter are shown in Figure 12. According to the results, it is noted that the sacrificial wastewater is more loaded than the Algerian urban wastewater for which the SS concentrations are between 350 mg/l and 570 mg/l (NSO 2018). Moreover, these average SS values in the analyzed wastewater vary between 668.07 and 866.83; they are clearly higher than the value set by the Algerian standards (JORA, 2006). The peak of the day appears from 9:30 a.m. to 11:00 a.m. for the three occasions studied (Figure 12). These concentrations are caused by the washing of the slaughter areas containing blood, the washing waters of the guts and the digestive contents, the debris discharged with the waters. The Algerian national standards (Executive Decree 06-141 of April 19, 2006/JORADP/23-04-2006) set a concentration of 40mg/l in TSS as a limit value in liquid effluents (domestic, industrial and agricultural).

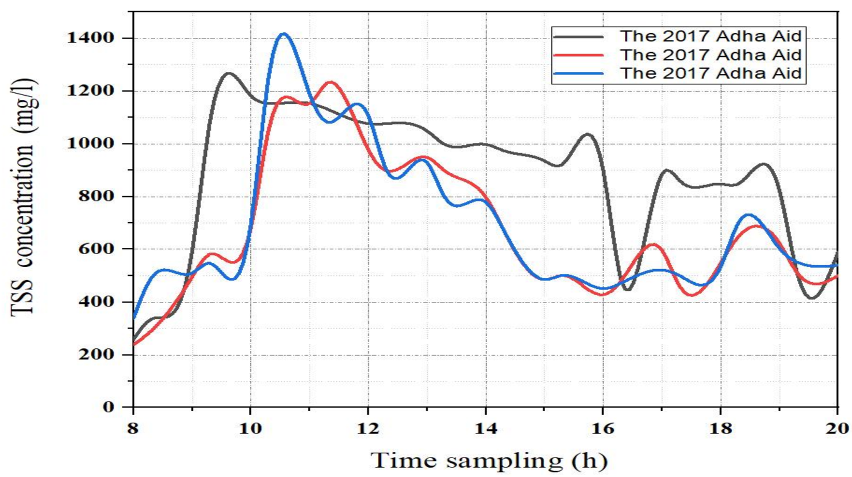


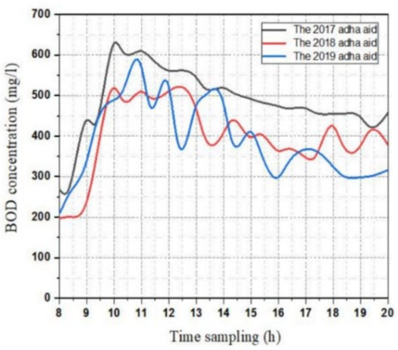
Figure 12 – Variation of suspended solids of waste water from slaughtering

Chemical and biochemical oxygen demand

Although COD should be considered an independent test of BOD_5 and will generate a higher concentration reading than BOD_5 for a particular wastewater sample, it is generally accepted that COD and BOD_5 share an empirical relationship.

The BOD_5 varies between 387.96 and 485.56 mg/l; these values could be explained by the fact that the share of biodegradable organic matter in this wastewater comes from the abundance of organic matter (rumen debris), by the concentration of this effluent by the blood of slaughter waste. COD makes it possible to assess the concentration of organic or mineral matter, dissolved or suspended in the water, through the quantity of oxygen necessary for their total chemical oxidation. The staining of slaughterhouse rejects is caused by blood from the slaughterhouse. Blood represents the major part of the COD of these liquid wastes. (Khennoussi et al, 2013).

The non-biodegradable organic matter is found in large quantities in this wastewater (high COD value) and comes mainly from various external sources with variable compositions of these non-biodegradable elements towards the network through the sacrificial waters. The variation of COD shows peaks, with a profile almost similar to that of BOD_5 (Figure 13). The first peak appears around 9:30 a.m. while the second (very pronounced) is observed around 10 a.m. and 11 a.m. during the day, the time of slaughter after the Eid prayer. The values observed are between 687.81 mg/l and 741.93 mg/l.



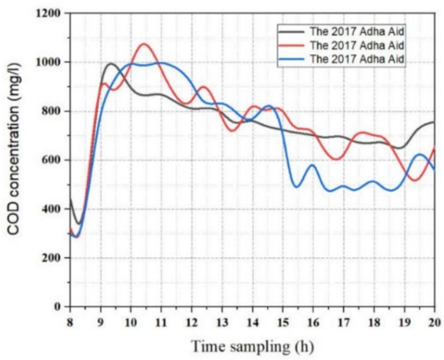


Figure 13 – Evolution of the organic pollution of waste water from slaughtering

There is a relationship between COD and BOD_5 because suspended solids include volatiles and ash, where the volatile part contributes to BOD_5. On the other hand, BOD_5 correlates very well with COD (R^2 = 0.98) (Figure 14) because the latter contributes to the oxidation of organic and inorganic matter, while BOD_5 contributes to organic matter (bacteria).

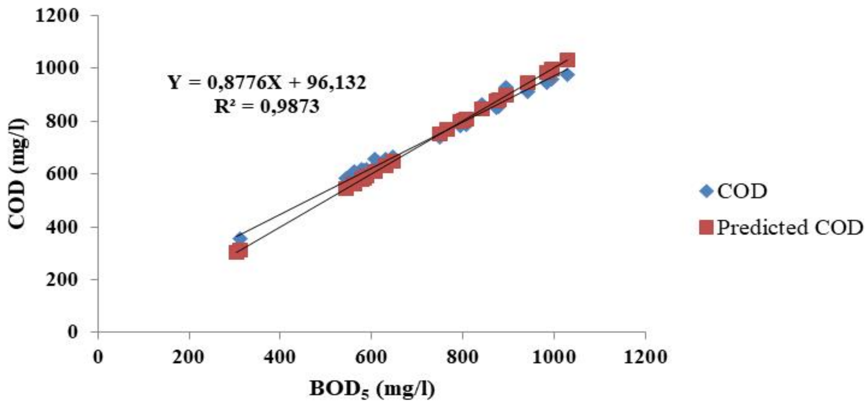


Figure 14 – Correlation between COD and BOD5 on the day of Eid Al-Adha

The results of the samples showed that for the various parameters analyzed, the pollution is very high in the morning. It reaches its peak around 11:00 a.m. and decreases between 12:00 p.m. and 1:00 p.m. during the lunch break, then it increases in the afternoon. This is due to cleaning operations.

Ratios

The use of these characterization parameters is a good way to give an image of the degree of pollution due to raw effluents and also to optimize the physicochemical parameters of wastewater to propose a suitable mode of treatment. The values of different ratios are given in Table 8.

Biodegradability is measured by the COD/BOD_5 ratio, which is used to assess raw water and determine the effluent biodegradability. The COD/BOD_5 ratio is important for determining an effluent purification cycle. Indeed, a low COD/BOD_5 ratio indicates the presence of a substantial fraction of biodegradable components, allowing a biological therapy to be considered. A high value of this ratio, on the other hand, shows that a major portion of the organic matter is not biodegradable, and it is advisable to pursue physical-chemical treatment in this scenario.

Observing the COD and BOD_5 levels on the same wastewater showed that the COD to BOD_5 ratio of the sacrificial wastewater will remain constant over time. The three Eid occasions have an average COD/BOD ratio of around 1.71.

In conclusion, the wastewater from this occasion has a high organic load. It is easily biodegradable and can be treated in the activated sludge treatment plant of Saida (Figure 15).

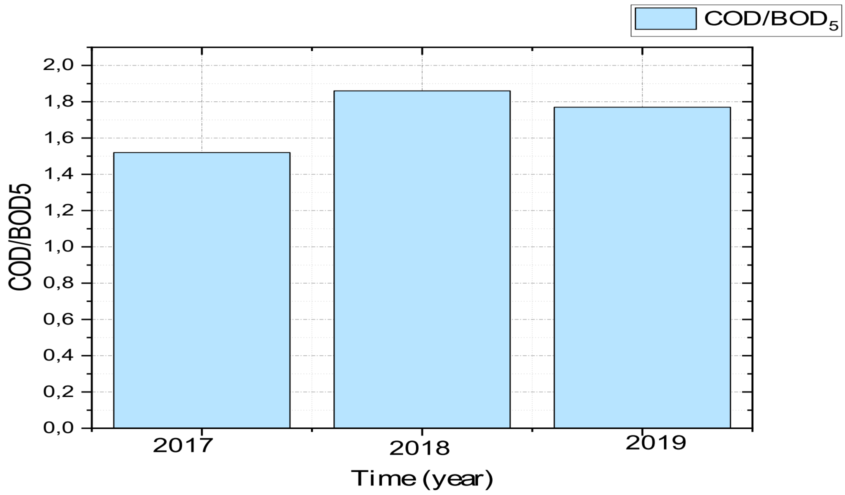


Figure 15 – Variation of biodegradability for the three occasions of Eid

The BOD_5/COD ratio gives a very interesting indication of the origin of pollution and its treatment options (Karefa et al, 2017). It is around 0.60; this effluent is biodegradable and confirms that these waters are loaded with organic (60%) and inorganic (40%) matter.

According to Rejsek (2002), this organic load makes this wastewater quite unstable; it rapidly evolves towards "digested" forms with the risk of releasing odors.

TSS/COD: The increase in the TSS/COD ratio is an index allowing one to suspect a phenomenon of resuspension of the deposits (during transport in the network). The found value of this ratio is between 0.90 and 1.16.

TSS/BOD5: The typical value for domestic wastewater for this ratio is between 1.65 and 1.75 and provides information on the production of sludge, a "natural" fraction provided by the TSS already present in the raw water. It indicates the distribution of particulate pollution and dissolved pollution. The average value of 1.72 indicates that the pollution is more granular than dissolved, which characterizes an essentially unitary network.

The index of organic pollution

According to the values of the organic pollution index (IPO) (Table 8), the pollution flow is classified as very strong organic pollution, as measured by the average of the number of classes of the four criteria (IPO = 1), owing primarily to discharges of very organic-rich sacrificial waters.

Table 8 – Relation between the pollution parameters

Ratios	2017	2018	2019
COD/BOD_5	1.54	1.90	1.75
BOD_5/COD	0.66	0.55	0.59
TSS/COD	1.16	0.90	1.09
TSS/BOD_5	1.75	1.65	1.75
BOD_5/TSS	0.60	0.64	0.59

Estimation of pollution loads

The polluting loads in (kg/d) are calculated from the concentrations in (mg/l) of the physical-chemical parameters, and an average of the occasional sacrifice flow and the wastewater flow discharged into the receiving environment (Saida river) without processing (Table 9).

Table 9 – Polluting loads in carbon, nitrogen and phosphorus pollution

	BOD5 (kg/d)	TSS (kg/d)	COD (kg/d)	NO_3^- (kg/d)	NH_4^+ (kg/d)	P_t (kg/d)
2017	9732.75	17375.07	14848.68	1082.99	2528.40	466.83
2018	7230.19	12165.71	13510.72	1176.93	1969.26	617.87
2019	6904.35	12211.82	12240.65	1158.91	2099.10	397.93

The calculated pollutant loads give an idea of the importance of the pollution brought to the receiving environment that day. The pollutant loads revealed that the samples are highly loaded with the organic matter in COD (Average = 13533.35 kg/d), in BOD_5 (Average= 7955.76 kg/d), in TSS (Average = 13917. 54 kg/d), the polluting loads of ammonium, nitrates, and total phosphorus Pt respectively of the order of 2198.92 kg/d, 1139.61 kg/d and 494.21 kg/d (Figure 16).

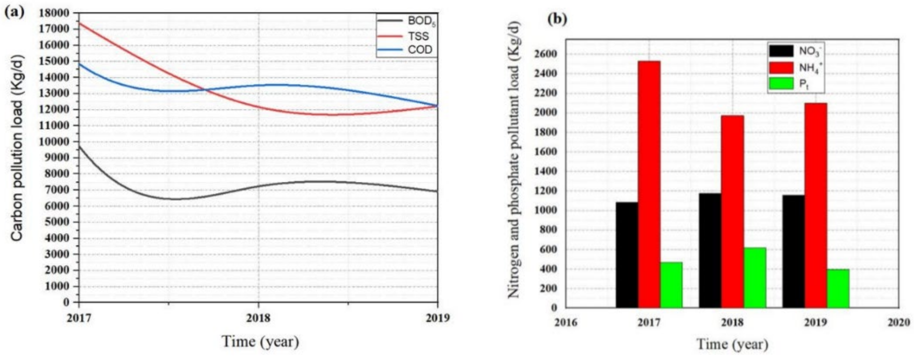


Figure 16 – Untreated polluting loads

Compared to the national and international standards for the discharge of wastewater into the natural environment (25 mg/l ≤ BOD_5 ≤ 100 mg/l and 125 mg/l ≤ COD ≤ 500 mg/l), loads of BOD_5 and COD in the Saida sacrifice wastewater exceed the permissible limits for the discharge of wastewater into the natural environment (surface water).

Conclusion

The quality of wastewater changes according to the sudden change in the inflow. The importance of identifying the problem of waste water discharges on the day of Eid Al-Adha is today an emergency measure. It is time for this issue to be among Algeria's national strategic concerns. Steps should be taken to better manage liquid waste and waste on the day of the sacrifice.

The discharge of wastewater on the day of Eid poses a serious environmental problem since it is highly loaded with organic matter. It is charged with blood, tripe contents, washing water, as well as solid particles such as animal hair, bones, offal, leather, etc., presenting panoply of pollutants which include proteins, fats, suspension, as well as pathogenic germs.

Both quantitatively and qualitatively, the monitoring of the wastewater studied shows that all the pollutants characterizing the pollution (BOD_5, COD, TSS, NH_4^+, NO_2^-, NO_3^- and P_t) show an increasing gradient in the morning for all samples taken, and a decreasing gradient at the end of the day. This increase in pollution is due to the nature of discharges after slaughter, inducing pollution which contributes to the total degradation of the quality of the receiving environment (Saida river).

After the assessment of the degree of organic pollution, the organic pollution index (IPO) of all the parameters studied (in particular with BOD5, COD, and SS) classifies the wastewater analyzed in the category of very strong organic pollution.

The Saida region is characterized by the presence of two types of aquifers, a superficial aquifer, and a Karstic aquifer. The presence of faults and cracks contribute to the contamination of the aquifers by these releases.

It is crucial for public health that these effluents be properly treated by an appropriate method to obtain a risk-free affluent. As the sanitation network is unitary, it is recommended to provide a buffer basin for this event, which could be useful in the event of heavy rainfall. The latter must be installed upstream of the WWTP for the recovery of blood to reduce the pollution load and treat water in the Saida WWTP that has sufficient capacity to treat this water before its discharge into the environment.

These recommendations open prospects that must be confirmed through intensification of local studies and further pathological analyses.

Nomenclature

pH Hydrogen potential
TSS Suspended Matter
COD Chemical Oxygen Demand
BOD Biochemical Oxygen Demand
MWR Ministry of Water Resources
NHO National Health Office
NH_4^+ Ammonium
NO_3^- Nitrates
NO_2^- Nitrites
Pt Total Phosphorus
Cl^- Chlorine
EC Electrical Conductivity
OPI Organic Pollution Index
WWTP Wastwater Treatement Plant

References

Al-Hejuje, M.M., Al-Saad, H.T. & Hussain, N.A. 2017. Assessing the Organic Pollution and Aquaculture Activity of Surface water at Shatt-Al-Arab Estuary Southern of Iraq. *ILMU KELAUTAN: Indonesian Journal of Marine Sciences (IJMS)*, 22(4), pp.161-168. Available at: https://doi.org/10.14710/ik.ijms.22.4.161-168.

Asibor, G., Edjere, O. & Azubuike, C. 2020. Status of discharged abattoir effluent and its effects on the physico-chemical characteristics of Orogodo river, delta state, Nigeria. *WIT Transactions on Ecology and the Environment,* 242, pp.51-60. Available at: https://doi.org/10.2495/WP200051.

Bayo, J. & López-Castellanos, J. 2016. Principal factor and hierarchical cluster analyses for the performance assessment of an urban wastewater treatment plant in the Southeast of Spain. *Chemosphere*, 155, pp.152-162. Available at: https://doi.org/10.1016/j.chemosphere.2016.04.038.

Belghyti, D., Guamri, Y.E., Ztit, G., Ouahidi, M., Joti, M., Harchrass, A., Amghar, H., Bouchouata, O., Kharrim, K.E. & Bounouira, H. 2009. Caractérisation physico-chimique des eaux usées d'abattoir en vue de la mise en oeuvre d'un traitement adéquat : Cas de Kénitra au Maroc. *Afrique Science: Revue Internationale des Sciences et Technologie*, 5(2), pp.199-216. Available at: https://doi.org/10.4314/afsci.v5i2.61730.

Bhave, P.P., Naik, S. & Salunkhe, S.D. 2020. Performance Evaluation of Wastewater Treatment Plant. *Water Conservation Science and Engineering*, 5, pp.23-29. Available at: https://doi.org/10.1007/s41101-020-00081-x.

Chennaoui, M. 2003. *Rejets d'abattoir des viandes rouges de la ville d'El Jadida : Caractérisation, impact sur la qualité du milieu marin récepteur et essai de valorisation en aliment animale.* PhD thesis. El Jadida, Morocco: Université Chouaib Doukkali, Faculté des Sciences [online]. Available at: https://toubkal.imist.ma/handle/123456789/6065?show=full [Accessed: 12 December 2024].

De Anda, J., López-López, A., Villegas-García, E. & Valdivia-Aviña, K. 2018. High-Strength Domestic Wastewater Treatment and Reuse with Onsite Passive Methods. *Water*, 10(2), art.number:99. Available at: https://doi.org/10.3390/w10020099.

Gautam, S.K., Sharma, D., Tripathi, J.K., Ahirwar, S. & Singh, S.K. 2013. A study of the effectiveness of sewage treatment plants in Delhi region. *Applied Water Science*, 3, pp.57-65. Available at: https://doi.org/10.1007/s13201-012-0059-9.

-ISO. 2025. *ICS 13.060.60 Détermination des propriétés physiques de l'eau* [online]. Available at: https://www.iso.org/fr/ics/13.060.60/x/p/1/u/1/w/0/d/0 [Accessed: 12 December 2024].

-JORA. 2003. Décret exécutif n° 03-451 du 7 Chaoual 1424 correspondant au 1er décembre 2003 définissant les règles de sécurité applicables aux activités portant sur les matières et produits chimiques dangereux ainsi que les récipients de gaz sous pression. *JORA Journal officiel de la Republique Algerienne Democratique et Populaire*, 42(75), décembre 7, pp.4-7. Alger: Direction et redaction secretariat general du gouvernement [online]. Available at: https://www.joradp.dz/FTP/jo-francais/2003/F2003075.pdf (in French) [Accessed: 12 December 2024].

-JORA. 2006. Décret exécutif n° 06-141 du 20 Rabie El Aouel 1427 correspondant au 19 avril 2006 définissant les valeurs limites des rejets d'effluents liquides industriels. Journal officiel de la République algérienne

Democratique et populaire. *JORA Journal officiel de la Republique Algerienne Democratique et Populaire*, 45(26), avril 23, pp.4-9. Alger: Direction et redaction secretariat general du gouvernement [online]. Available at: https://www.joradp.dz/FTP/jo-francais/2006/F2006026.pdf (in French) [Accessed: 12 December 2024].

Karef, S., Kettab, A., Loudyi, D., Bruzzoniti, M., Del Bubba, M., Nouh, F., Boujelben, N. & Mandi, L. 2017. Pollution parameters and identification of performance indicators for wastewater treatment plant of Medea (Algeria). *Desalination and Water Treatment,* 65, pp.192-198. Available at: https://doi.org/10.5004/dwt.2017.20290.

Khennoussi, A., Chaouch, M. & Chahlaoui, A. 2013. Treatment of the effluent from a red meat slaughterhouse by electrocoagulation flotation with iron electrodes. *Revue des sciences de l'eau/Journal of Water Science*, 26(2), pp.81-171. Available at: https://doi.org/10.7202/1016064ar.

Kokkinos, P., Mandilara, G., Nikolaidou, A., Velegraki, A., Theodoratos, P., Kampa, D., Blougoura, A., Christopoulou, A., Smeti, E., Kamizoulis, G., Vantarakis, A. & Mavridou, A. 2015. Performance of three small-scale wastewater treatment plants. A challenge for possible re use. *Environmental Science and Pollution Research International*, 22, pp.17744-17752. Available at: https://doi.org/10.1007/s11356-015-4988-3.

-NHO National Health Office. 2017. *Management and operating report of the wastewater treatment plant in the city of Saida*. Saida, Algeria: NHO National Health Office.

Peiffer, G. 2002. *Impact environnemental des effluents d'abattoirs : Actualités techniques et réglementaires.* Médecine vétérinaire et santé animale [online]. Available at: https://dumas.ccsd.cnrs.fr/dumas-04655172v1 [Accessed: 12 December 2024].

Rejsek, F. 2002. *Analyse des eaux: Aspects réglementaires et techniques*, *Broché – 1*. Canopé - CRDP de Bordeaux. ISBN: 978-2866174200.

Rodier, J. 1975. *Analysis of Water*. John Wiley & Sons. ISBN: 978-0470729342.

Walter, R.H., Sherman, R.M. & Downing, D.L. 1974. Reduction in oxygen demand of abattoir effluent by precipitation with metal. *Journal of Agricultural and Food Chemistry*, 22(6), pp.1097-1099. Available at: https://doi.org/10.1021/JF60196A015.

Evaluación del impacto ambiental de las aguas residuales urbanas y de la capacidad de tratamiento de la planta de lodos activados de Saida (noroeste de Argelia) con motivo del Eid Al-Adha

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CAMPO: tecnología química, ciencia ambiental
TIPO DE ARTÍCULO: artículo científico original

Resumen:

Introducción/objetivo: La matanza de ganado durante el Eid Al-Adha genera cantidades significativas de aguas residuales ricas en contaminantes orgánicos. Sin embargo, el impacto específico de estos efluentes en la calidad del agua sigue estando poco documentado. Este estudio tuvo como objetivo evaluar las cargas contaminantes vertidas en el valle de Saida durante el Eid Al-Adha y evaluar la capacidad de tratamiento de la planta de tratamiento de aguas residuales (PTAR) local con lodos activados.

Métodos: Se recogieron muestras de agua de diferentes puntos del sistema de alcantarillado en distintos momentos del día durante tres eventos de Eid Al-Adha (2017, 2018 y 2019). Se analizaron varios parámetros fisicoquímicos, entre ellos temperatura, pH, conductividad eléctrica, demanda química de oxígeno (DQO), demanda bioquímica de oxígeno a cinco días (DBO_5), sólidos suspendidos totales (SST), amonio, nitratos, nitritos y fósforo. Para evaluar el cumplimiento, Los niveles de contaminación medidos se compararon con las normas reglamentarias argelinas.

Resultados: Los análisis revelaron un aumento brusco de los niveles de contaminación por la mañana, seguido de una disminución gradual por la tarde. Las altas cargas contaminantes procedentes de los efluentes de matanza degradaron significativamente la calidad del agua del río Saïda. El índice de contaminación orgánica clasificó estos vertidos como muy contaminantes. El aporte excesivo de materia orgánica y nutrientes provocó un agotamiento del oxígeno y riesgos de eutrofización.

Conclusión: El vertido de aguas residuales de matanza sin tratar plantea graves riesgos para la salud pública y el medio ambiente. Para mitigar estos impactos es esencial reforzar las estrategias de gestión de las aguas residuales durante el Eid al-Adha, mejorar los procesos de tratamiento en la planta de tratamiento de aguas residuales de Saïda y aplicar normas ambientales estrictas.

Palabras claves: Eid Al-Adha, EDAR de lodos activados, biodegradabilidad, carga contaminante, medio receptor, aguas residuales.

Оценка воздействия городских сточных вод на окружающую среду и эффективности очистки активного ила очистным сооружением в городе Саида на северо-западе Алжира во время праздника Курбан-Байрам

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РУБРИКА ГРНТИ: 61.01.94 Охрана окружающей среды
ВИД СТАТЬИ: оригинальная научная статья

Резюме:

Введение/цель: При убое скота во время праздника Курбан-Байрам образуется значительное количество сточных вод, содержащих органические загрязнители. Однако конкретное воздействие этих сточных вод на качество воды остается недостаточно исследованным. В данной статье представлена оценка количества загрязняющих веществ, сбрасываемых в долину Сайда во время праздника Курбан-Байрам, и оценку мощности местной станции очистки сточных вод от активного ила (WWTP).

Методы: Образцы воды трижды были отобраны из разных точек канализационной системы в разное время суток во время праздника Курбан-Байрам (2017, 2018 и 2019). Были проанализированы несколько физико-химических параметров, включая температуру, pH, электропроводность, химическое потребление кислорода (ХПК), пятидневное биохимическое потребление кислорода (БПК$_5$), общее содержание взвешенных веществ, аммония, нитратов, нитритов и фосфора. Измеренные уровни загрязнения были сопоставлены с алжирскими нормативными стандартами с целью оценки соответствия.

Результаты: Анализ результатов выявил резкое повышение уровня загрязнения в утренние часы, за которым последовало

постепенное снижение к вечеру. Высокое содержание загрязняющих веществ в сточных водах, образующихся при убое скота, значительно ухудшило качество воды в реке Сайда. По индексу органического загрязнения эти выбросы классифицированы как экстремально высокие загрязнители. Чрезмерное поступление органических и питательных веществ привело к истощению запасов кислорода и риску от эвтрофикации.

Вывод: Сброс неочищенных сточных вод со скотобойни представляет серьезную угрозу для окружающей среды и здоровья населения. Для смягчения таких последствий необходимы совершенствование стратегий управления сточными водами во время праздника Курбан-Байрам, совершенствование процессов очистки на станции очистки сточных вод в Саиде и соблюдение строгих экологических стандартов.

Ключевые слова: Курбан-байрам, очистное сооружение, активный ил, биоразлагаемость, нагрузка загрязняющих веществ, водоприемник, сточные воды.

Процена утицаја градских отпадних вода на животну средину и капацитет пречишћавања активираног муља у постројењу за пречишћавање отпадних вода у граду Саиди на северозападу Алжира током Курбан-бајрама

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ОБЛАСТ: хемијске технологије, заштита животне средине
КАТЕГОРИЈА (ТИП) ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: Клање стоке током Курбан-бајрама доводи до стварања великих количина отпадне воде богате органским загађивачима. Међутим, специфични утицај ових комуналних отпадних вода на квалитет воде још није довољно истражен. Циљ ове студије јесте *да процени контаминацију загађивачима који се испуштају у долину Саиде током Курбан-бајрама, као и да процени капацитет пречишћавања активираног муља локалног постројења за пречишћавање отпадних вода (wastewater treatment plant -WWTP).*

Методе: Узорци воде су прикупљани са различитих места у канализационом систему током различитих делова дана за време одржавањаКурбан-бајрама 2017, 2018. и 2019. године. Анализирано је неколико физичко-хемијских параметара као што су температура, pH вредност, електрична проводљивост, хемијска потрошња кисеоника (chemical oxygen demand – COD), петодневна биохемијска потрошња кисеоника (biochemical oxygen demand – BOD_5), укупне суспендоване честице, амонијак, нитрати, нитрити и фосфор. Измерени нивои загађености упоређени су са алжирским законским стандардима како би се утврдило да ли и у коликој мери одступају од њих.

Резултати: Анализе су показале да ниво загађености нагло расте током јутра, а постепено се смањује током вечери. Велики садржај загађивача из отпадних вода након клања знатно је умањио квалитет воде у реци Саиде. Индекс органског загађења класификује ове отпадне воде као изузетно загађене. Прекомерни унос органских материја и нутријената довео је до смањивања количине кисеоника и до ризика од цветања воде.

Закључак: Испуштање непречишћене отпадне воде од клања стоке представља озбиљан ризик по животну средину и јавно здравље. Побољшавање стратегија управљања отпадним водама током Курбан-бајрама, унапређивање процеса пречишћавања у постројењу за пречишћавање отпадних вода у Саиди, као и спровођење строгих прописа у заштити животне средине од суштинске су важности за смањење ових негативних утицаја.

Кључне речи: Курбан-бајрам, постројење за пречишћавање активираног муља из отпадних вода, биоразградивост, оптерећење загађујућим материјама, водопријемник, отпадне воде.

Paper received on: 14.12.2024.
Manuscript corrections submitted on: 26.03.2025.
Paper accepted for publishing on: 27.03.2025.