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Phycolimnological study of some wastewater of Sulaimani Provience -Kurdistan Region of Iraq

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Abstract

This work is aimed to study the characteristics of some wastewater in Sulaimani city. Water samples were collected monthly from October 2018 to May 2019 from four sites, two of them Site1:Tanjaro River before bridge,Site 2:Tanjaro River after bridge along Tanjaro river , Site3:kana swra and Site4:Awbara from weast water of Sulaimani city box channels which finally flow into Tanjaro river . To represent their water quality some physical , chemical and Biological analysis were conducted. The mean value of pH for all studied sites was found to be above 7 . The value of Electrical conductivity(EC) in Sites 1,2,3 and 4 were ranged between(407-601 µs/cm),(266-585 µs/cm) ,(773-1004 µs/cm) and(398-975 µs/cm)respectively, Turbidity ranged between(42-1001 NTU),(57-986 NTU),(32-1010.5 NTU) and(41-643 NTU) in Site 1,2,3 and 4 respectivly and Chemical Oxygen Demand (COD) value in Site 1,2,3 and 4 were ranged between(251-975.5 mg/L),(275-926 mg/L),(354-1025 mg/L) and(452-1025 mg/L) respectively. A total of 114 algal taxa were identified belonging to 7 classes, 63 taxa belonged to Bacillariophyceae species, they were the most abundant group (4 taxa belong to centrales and 59 taxa belonging to pinnales), followed by 24 taxa of Cyanophyceae ,22 taxa chlorophyceae, , 2 taxa Pyrophyceae and 1 taxa for each of Euglenophyceae , Rhodophyceae and Xanthophyceae. Higher phytoplankton density was recorded in Awbara (58269.44ind×10^3/L), while the lowest density was recorded in Tanjaro River after the bridge which was (14300.2ind×10^3/L) .

Introduction

Water is one of the natural resources that are essential for the existence of every living organisms as well as the ecological system [1]. Water is always has been the foundation of many well known civilizations and today it is the essential element for activities like agricultural, economic and industrial, which helps societies and nationwide development [2]. Natural water bodies receive a major proportion of various wastewater [3]. With the advent of technology, there is an increasing amount of waste that originates from anthropogenic activities having a negative impact on the environment and particularly the quality of irrigation and drinking water [4, 5]. The Iraqi Kurdistan region suffers from sewerage system problems. However, poor practice of using water raises serious questions on how water is supplied to different cities including Sulaimani, This area has several industrial sites as well as oil refineries, sewage from many of the Sulaimani neighbourhood discharge and dumped their wastewater into the Tanjaro river which runs south of the city. Different types of wastewater flow into the river, includes agricultural,domestic , industrial waste and stochastic throwing of pathological and commercial wastes [6]. The dramatic impact of water pollution on the human health is sinks for wastes. The deliberate human waste discharge into the water bodies brought about distinct modifications of the environmental water quality. Hence, making a great deal of the quantities of water bodies unsuitable for various uses [7]. In addition, water pollution is considered as a major threat to the process of food production and is raising both human health as well as environmental concerns. One of the emerging environmental issues is the case of compromise in the quality of the environment resulting from acontinuous effluent discharge of the waste in many countries especially in the developing countries [8]. Scientific studies revealed that wastewater consists of 99.9% of clean water, but only 0.1% of solids or undesirable species cited by Amin, 2018 [9]. Phytoplankton, as a primary producer, plays an important role in many aquatic ecosystems. thus they are the first link in the food chain, and generally cause nuisance environmental conditions [10]. As stated by Descy, 1993 [11] algal flora is a crucial indicator of water pollution and bloom in almost all water bodies that receive agriculture waste, domestic water and household waste. Algae particularly diatoms are generally accepted as one of the most suitable bioindicators of the aquatic ecosystem for water quality monitoring and organic pollution [12]. Growth of sine specific algae requires specific environmental conditions and therefore, their distribution pattern, periodicity and productivity vary from one water body to another. However, algal species, community structure, fine spatial distribution and biomass vary day to day, season to season as affected by various environmental factors [13]. The objective of this work is to analyze the physical, chemical variables and identify the algal composition of polluted wastewater sites to get a better understanding of these influences to water quality.

Materials and methods

Study Area

Kurdistan region of Iraq is located approximately between the SN latitude 34° 30′ and 37°20′; and the WE longitude 42°20′ and 46°20′ [14]. Sulaimani center is located at an altitude of 2895 feet above sea level [15] . In present the study four Sites were selected: site (1)Tanjaro river before the bridge near an industrial area, Site 2 Tanjaro river after the bridge sand and gravel mining area, site (3) kana swra wastewater and site (4) Awbara wastewater from Sulaimani city wastewater box channels which finally flow into Tanjaro river . The actual point of the studied sites was determined by Global Position System (GPS) model (GARMIN e-Map) as shown in (Table 1) and (Figure ,1)

Table(1)The actual points of the sites of the wastewater (GPS).

Site	Name of Sites	(GPS) reading by G.E.A.		
		latitude	longitude	Altitude m.a.s.l
1	Tanjaro River before bridge	35° 28' 41.721"N	45° 25' 36.873E	648
2	Tanjaro River after bridge	35° 28' 49.474"N	45° 26' 07.224E	643
3	Kana swra Waste water	35° 31' 58.769"N	45° 23' 17.166E	734
4	Awbara Waste water	35° 32'55.168"N	45° 22'51.332"E	727

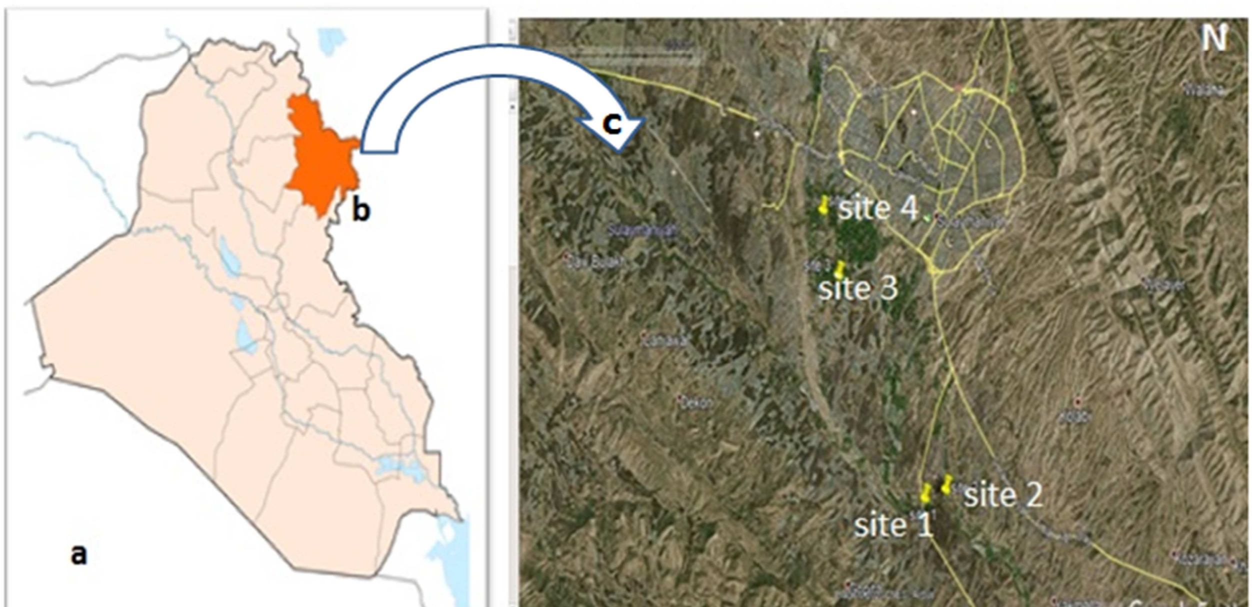

Figure 1. Maps show:**a-** Iraq ,**b:**Sulaimani province,**c-**location of studied sites

Samples collection:

Samples were taken from four Sites monthly during October 2018 to May 2019. In order to determine the quality of wastewater, water samples were collected from surface water (30-40 cm depth). For physical and chemical tests polyethylene bottles pre-washed by water sample twice before filling were used. All field meters and equipment were checked and calibrated using appropriate solutions. The parameters analyzed were water temperature (using a mercury thermometer (range -10 to 50 ºC), pH, EC and TDS were measured by(EUTECH INSTRUMENT)(CYberScan PC 300), the results were expressed as µS/cm for EC and (ppm) for measured TDS. Turbidity(NTU) mesasured byTurbidity meter(WQ770) Glober water, dissolved oxygen (DO) was measured directly in the field by using dissolved oxygen meter Hl 9142 (HANNA instrument) results were expressed as mg/L. NO_3, PO_4, BOD_5, and COD were measured according to the standard methods [16,17].

Phytoplankton Analysis

Quantitative analysis

Phytoplankton total number count (ind×10^3/L), was performed by using the sedimentation method [18].

Qualitative analysis

Non-diatomic algae were identified by preparing slides and examined under 40 X by using a compound microscope depending onthe following references which were used for the identification of non-diatomic algae [19-22].

While diatoms were identified after dissolving the organic matter by using nitric acid and examined under 100 X depending on [23,24].

Statistical analysis

Statistical analysis of the data was done by a software program (XLSTAT 2019,version 3.2), TWO WAY ANOVA(multiple comparisons Duncan test) analysis of variance which was adopted to analyse the data to determine significant differences between parameter,Months and sites and compared the means in the level of ($P \leq 0.05$).

Results and Discussion

Throughout this study,the characteristics of some waste water are shown in (Table 2). The water temperature values ranged from 12.0°C in site3 during December 2018 and its higher value(26.0ºC) recorded in April 2019 in site 2 (Figure,2) results indicate that the variation of water temperature values was affected by elevation, sunlight intensity and direction , sunlight increases the temperature of surface water depends largely upon categorizing of geographic location and climate [25-27].The climate of the area is related to Irano-Turanian type [28].

The values of pH were ranged between of (6.6–8.0)as showed in (Figure, 3).In Kurdistan region of Iraq, the pH of water is characterized by a shift towards the alkaline side of neutrality, due to the geological formation of the area .ASimiler results obtained by study of [29- 32] they recorded that the pH value were ranged between (5.7-8.2) ,(7.0-8.1) and (6.7-8.3) in duhok vally, wastewater channel of Erbil city and dukan lake water respectively. Increase of pH value may be due to the nature of pollutants which reach the wastewaters sites, such as fertilizers and cleaning agents, detergents that has alkaline effect on the water [30,33,34,35].

Table(2)physico-chemical properties of the studied area,data represented as minimum, maximum, mean±S.E, during October 2018-May 2019

Sites / Parameters	Mean±S.E			
	Site1	Site 2	Site 3	Site 4
Water temperature(ºC)	14-23[c] 17.5±1.21	13-26[c] 17.5±1.45	12-25 [b] 19.7±1.48	15-25[a] 20.1±1.41
PH	6.6-7.6 [b] 7.22±0.12	6.9-7.6 [b] 7.30±0.07	7.1-7.9 [a] 7.46±0.09	6.9-8.0 [a] 7.45±0.13
Electrical conductivity(µs/cm)	407-601 [c] 482±26.00	266-585 [d] 432.25±33.66	773-1004 [a] 867.25±29.00	398-975 [b] 721.5±76.64
Total dissolved Solid (ppm)	133-284 [d] 207.5±19.87	146-317[c] 213.25±20.64	378-468 [a] 430.25±11.69	241-509 [b] 396.875±31.12
Turbidity(NTU)	42-1001 [b] 369.62±119.82	57-986 [a] 541.75±146.60	32-1010.5 [c] 229.93±116.43	41-643[d] 210.75±69.64
Dissolved Oxygen(mg/L)	3.1-6.8 [a] 5.45±0.41	3.2-7.0 [a] 5.52±0.40	3.5-7.1 [b] 4.80±0.38	3.1-5.8 [c] 4.62±0.32
Biological Oxygen Demand(mg/L)	80-360 [c] 139.75±32.44	52-287[d] 130.62±25.26	93-304 [b] 177.87±21.78	83-324 [a] 209.87±32.58
Chemical Oxygen Demand(mg/L)	251-975.5[d] 484.43±103.86	275-926[c] 517.62±93.11	354-1025[b] 654.875±105.10	452-1025[a] 722.62±89.84
Nitrate(NO_3)(mg/L)	0.45-6.66 [a] 2.92±0.72	0.41-5.22 [c] 2.58±0.55	0.28-3.49 [d] 1.43±0.37	0.69-7.62 [b] 2.80±0.76
Posphate(PO_4)(mg/L)	0.18-5.88 [c] 2.56±0.74	0.18-5.87[d] 2.17±0.74	0.18-24.0 [b] 8.80±2.84	7.09-27.83 [a] 16.31±2.87

*value in each rows with same letters are not significantly difference at ($p \leq 0.05$) ,value with different letters are significantly different.

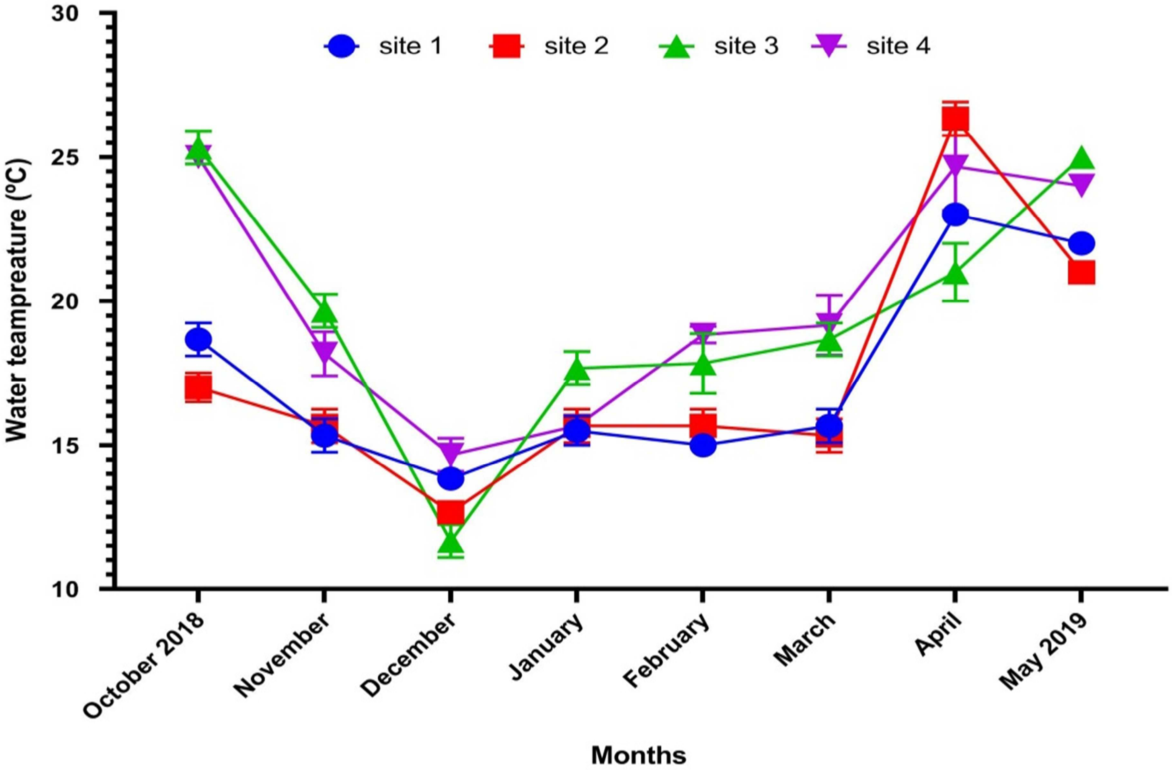

Figure2. Spatio-temporal variations of water temperature(ºC) of sulaimani wastewater.

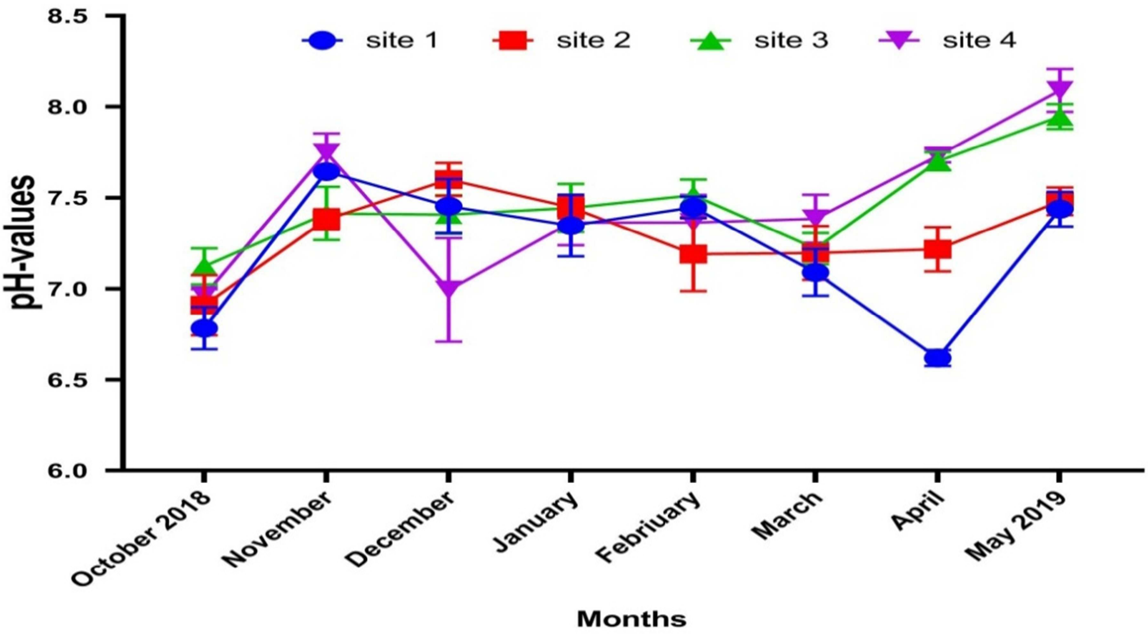

Figure3. . Spatio-temporal variations of PH value of sulaimani wastewater.

The results of electrical conductivity and total dissolved solids in this investigation ranged between (266 - 1004) µS/cm and (133 - 509) ppm respectively, asignificant difference was observed among the months and sites. (Figure, 4 and 5).the lowest value of EC recorded in rainy months might be related to the dilution and the highest flow of wastewater. The decreases in the EC and TDS related to the lack of concentration of dissolved salts, that utilization by phytoplankton. These results match with many other studies of [30,36,37]. Increasing of TDS in the waste waters coincided with the increase of water temperature that affected by the level of dissolved solids in the water body, fertilizer run-off, wastewater and septic effluent, soil erosion , decaying plant and animals ,and geological features of the studied area [38-40].

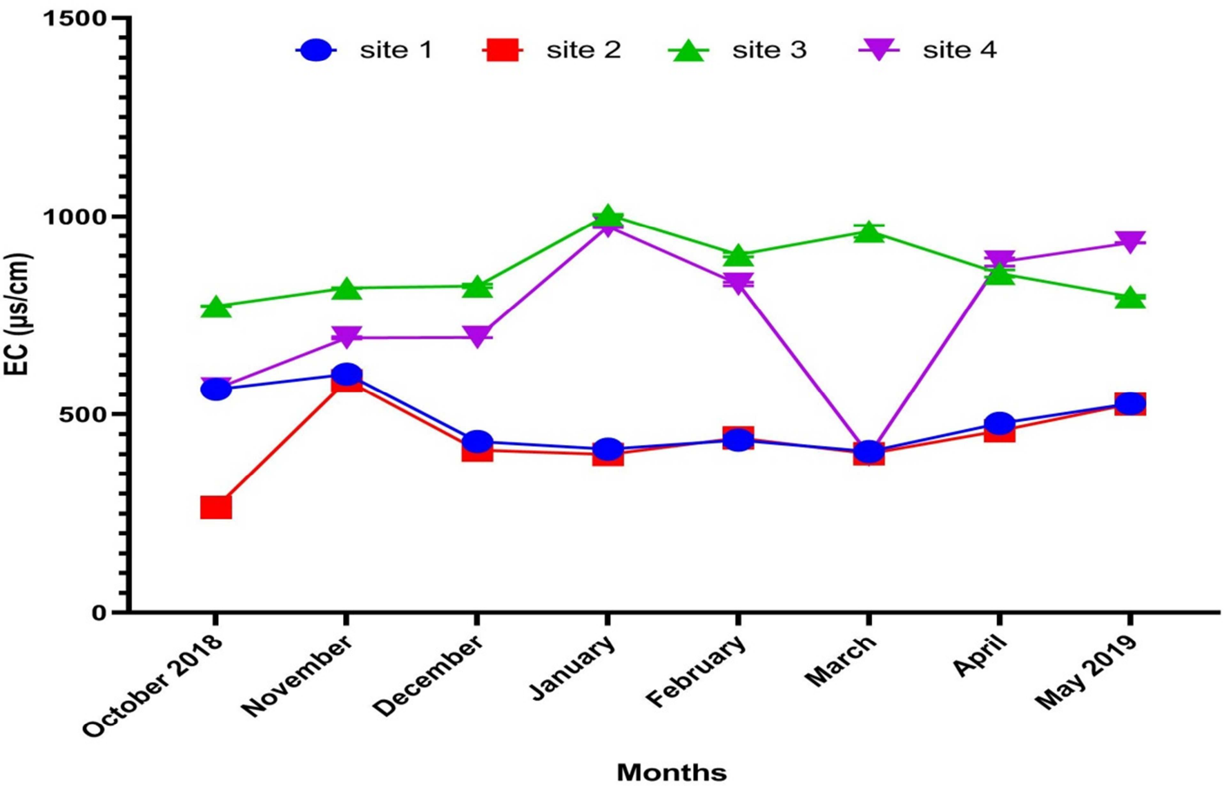

Figure4. Spatio-temporal variations of Electrical conductivity of sulaimani wastewater

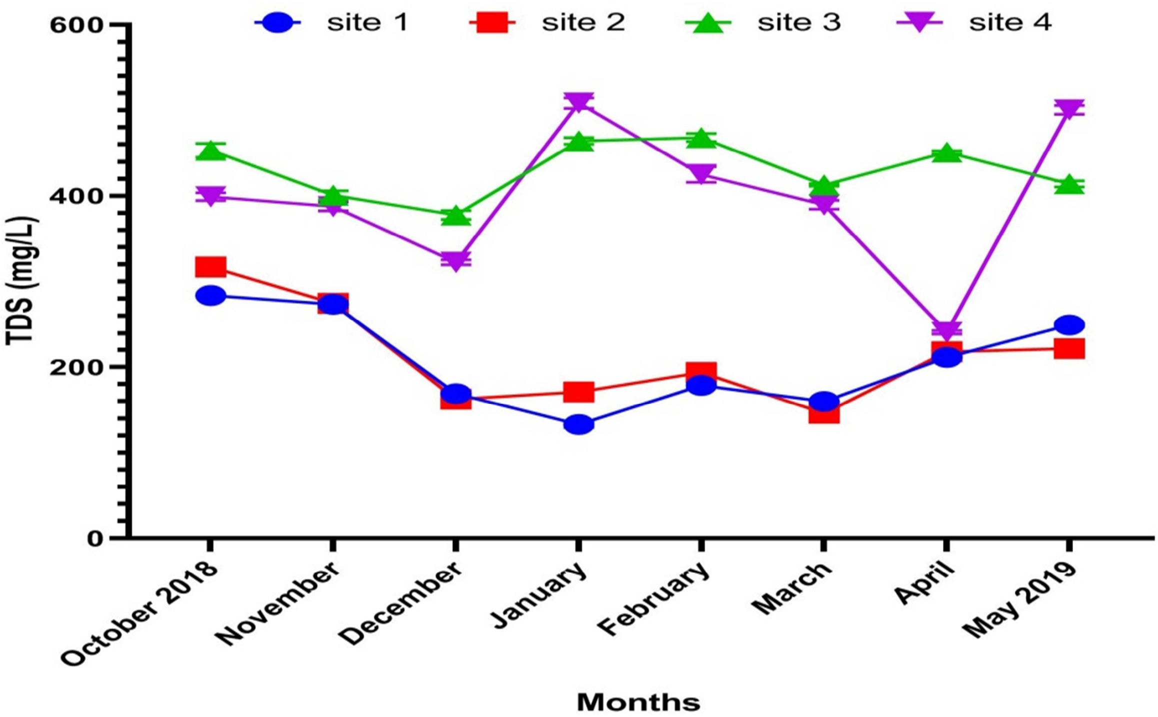

Figure5. Spatio-temporal variations of Total Dissolved Solids of sulaimani wastewater

Turbidity value ranged between (32-1010.5) NTU in the studied area (figure,6). Turbidity is the amount of suspended matter such as clay, silt, inorganic matter , organic matter and algae density [8 ,41]. The highest Dissolved oxygen recorded 7.1mg/L was in site 3 in February 2019 while lowest dissolved oxygen values were observed in sites 1 and 4 during March 2019 (figure, 7) . Dissolved oxygen concentration was affected by water temperature, water movement and salinity [42], and especially dependent on biological activities such as photosynthesis ,respiration and consumption by living organisms like bacteria similar results observed by [43-46 ,33].

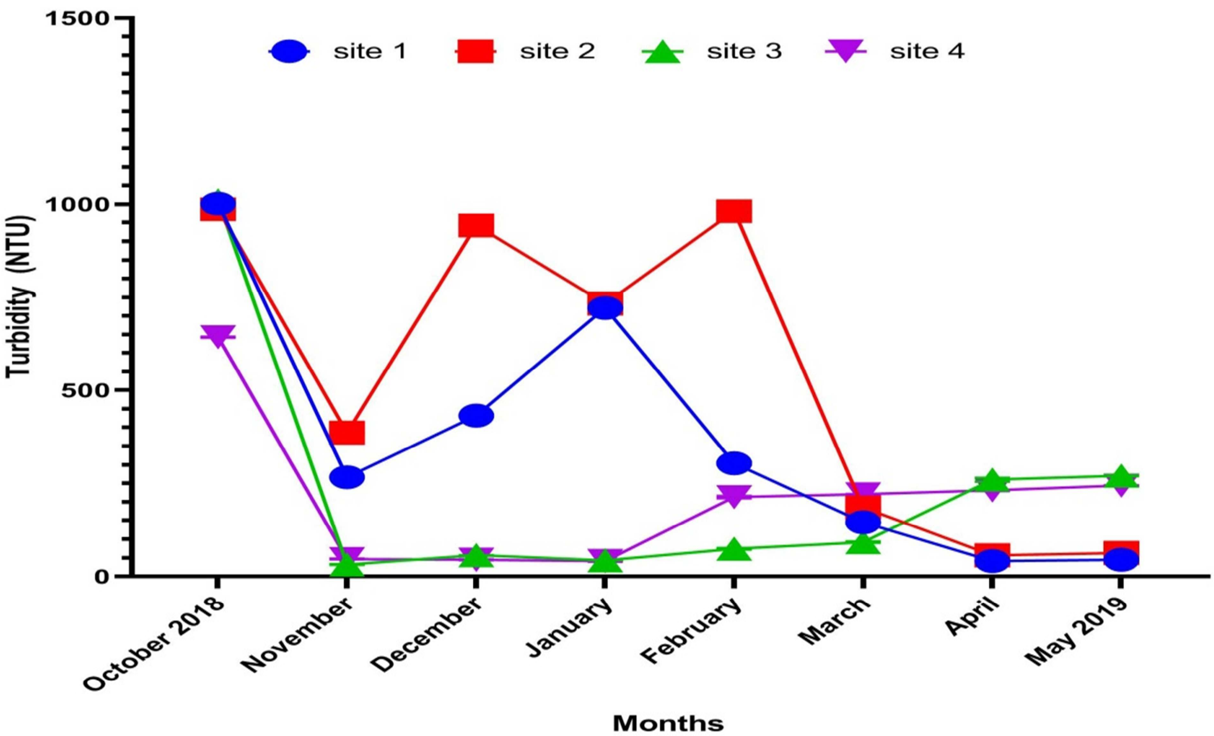

Figure6. Spatio-temporal variations of Turbidity of sulaimani wastewater

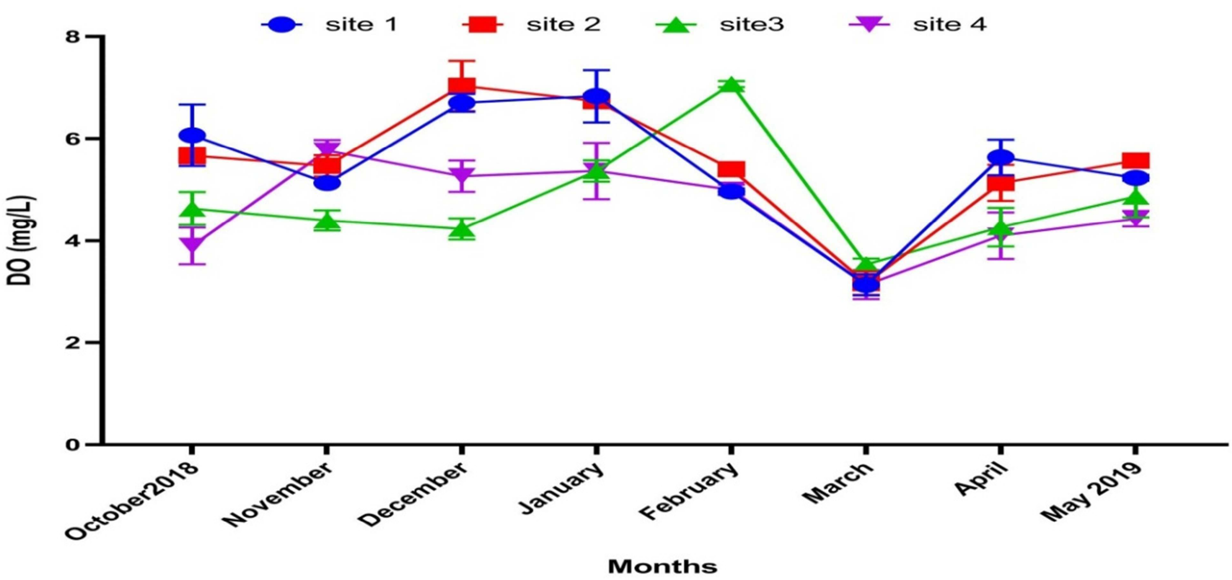

Figure7. Spatio-temporal variations of Dissolved Oxygen of sulaimani wastewater

Biological oxygen demand concentration was ranged between (52 - 360) mg/L, (Figure, 8). the highest concentration recorded in sites1 and 4, it be due to discharging of domestic, industrial and agricultural wastes to the waters continuously, and the effects of temperature on the activity of the microorganisms leads to increasing the BOD_5 ratio in the wastewater as indicated by [47-49] , previous studies showed that the BOD_5 value for untreated city sewage water ranged from 100-400 mg/L [50]. The highest and lowest COD value of the study area are ranged between (251-1025)mg/L. Statistical results showed significant differences at ($P \leq 0.05$) between months and sites (sites1 and 2) and (sites3 and 4) (Figure, 9) . Concentrations of BOD_5 and COD could constitute potential pollution problems to the water bodies since it contains high organic compounds that require large amounts of oxygen for degradation. In terms of wastewater strength, the average concentration of BOD_5 and COD in domestic wastewater, are recorded to range from 110 to 350 and 250 to 800 mg/L respectively by [51]. The value of COD was higher than the value of BOD_5 during the period of the study. Generally, this indicates that less number of compounds can be biologically oxidized than the number which can be chemically oxidized [52]. Same results was observed by [46,49,53] they showed that the BOD_5,COD values ranged between (162.8–974.7)mg/L, (543–1231) mg/L in paint industrial wastewater of Nigeria recpectively, while The average values of BOD_5(173) mg/L, COD(386) mg/L were investigated from Al-Sadr Teaching Hospital wastewater in Basra city and The COD value were ranged between (280- 1410) mg/L in hospitals wastewater of Erbil city.

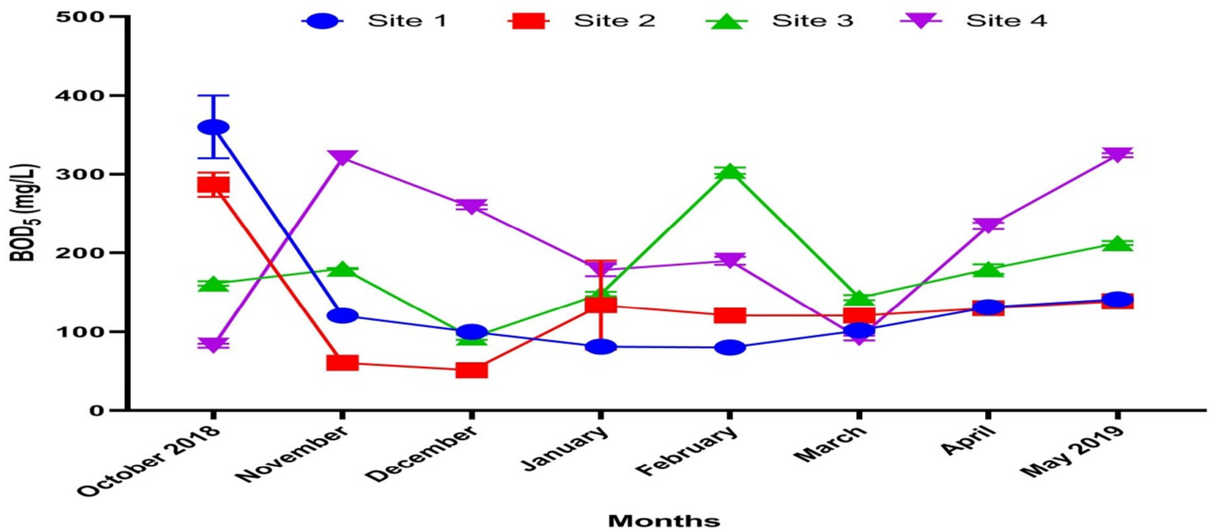

Figure8. Spatio-temporal variations of BioChemical Oxygen Demand of sulaimani wastewater

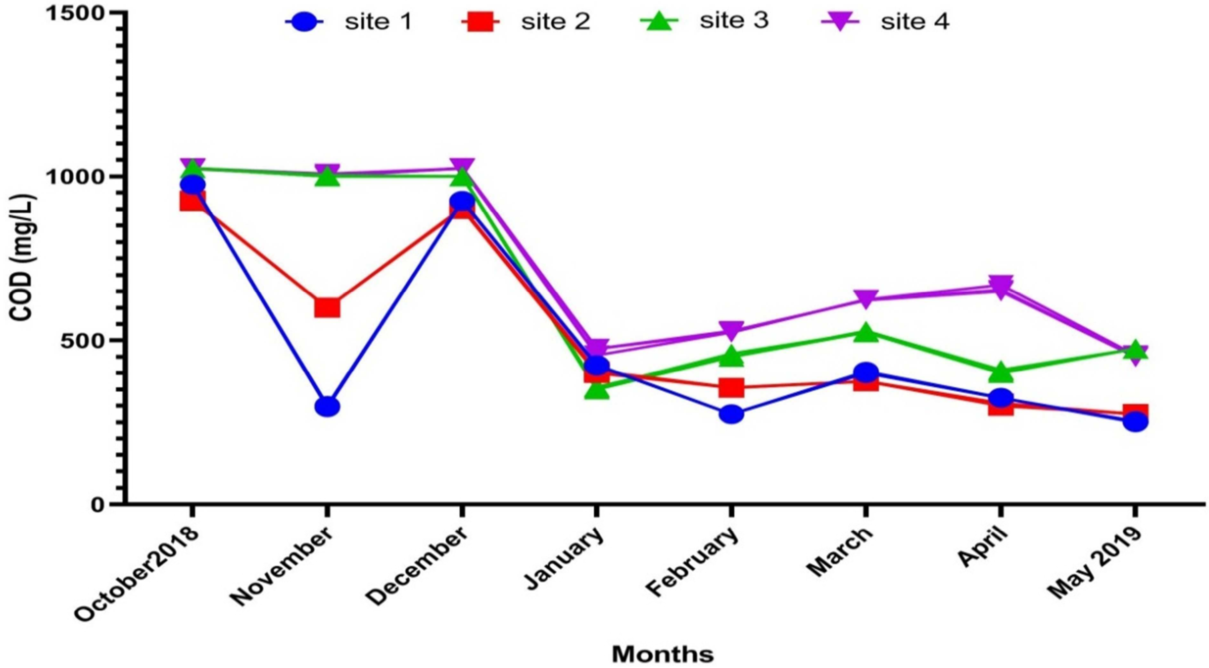

Figure9. Spatio-temporal variations of Chemical Oxygen Demand of sulaimani wastewater

Nitrate values varied between 0.285 and 7.624 mgN-NO_3/L during this study . Higher nitrate concentrations were recorded in site 4 during May 2019 .(Figure, 10) This may be related to significant sources of nitrate which are chemical fertilizers from cultivated land and drainage from livestock feedlots, as well as domestic sewage and rainfall [54,55].

The range of Phosphate recorded were between 0.18 and 27.84 mg P.PO_4/L. statistically differences ($P \leq 0.05$)were observed between months in the studied area (Figure,11). The Maximum value of PO_4 in site 4 may be due to detergents used for cleaning contained polyphosphate compounds and algae activities. The excess content of phosphorus in receiving waters leads to extensive algae growth which caused (eutrophication).In the aquatic environment concentration of phosphorus supports algal bloom is ranged between 0.005 to 0.05 mg/l [56 ,44].

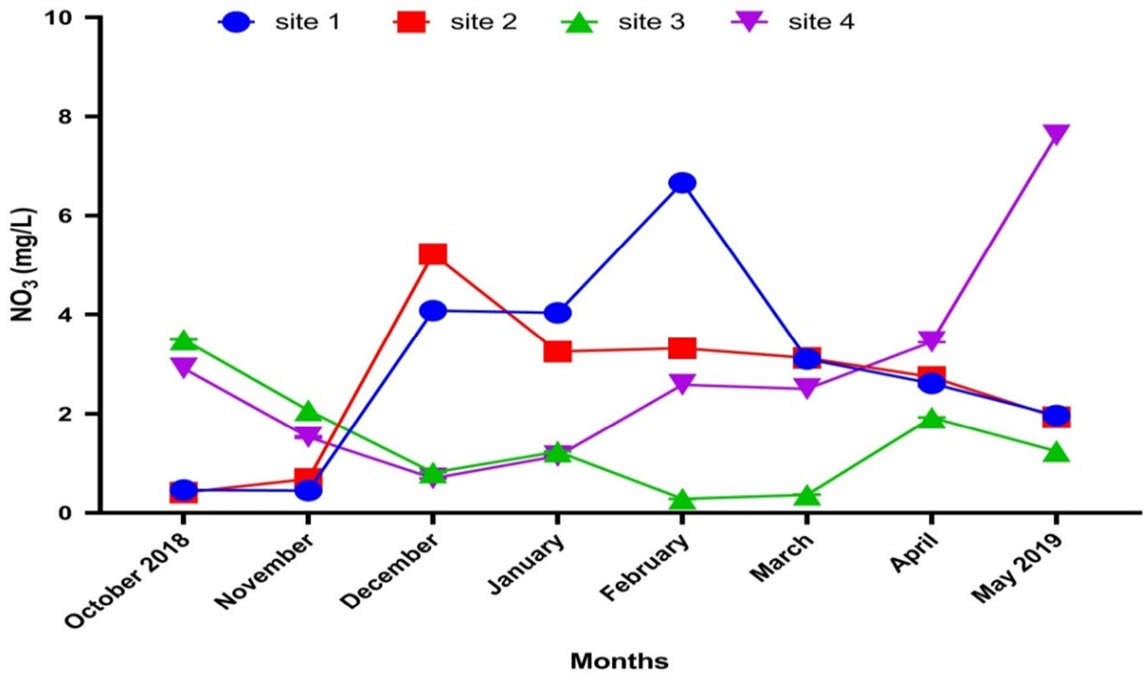

Figure10. Spatio-temporal variations of Nitrate of sulaimani wastewater

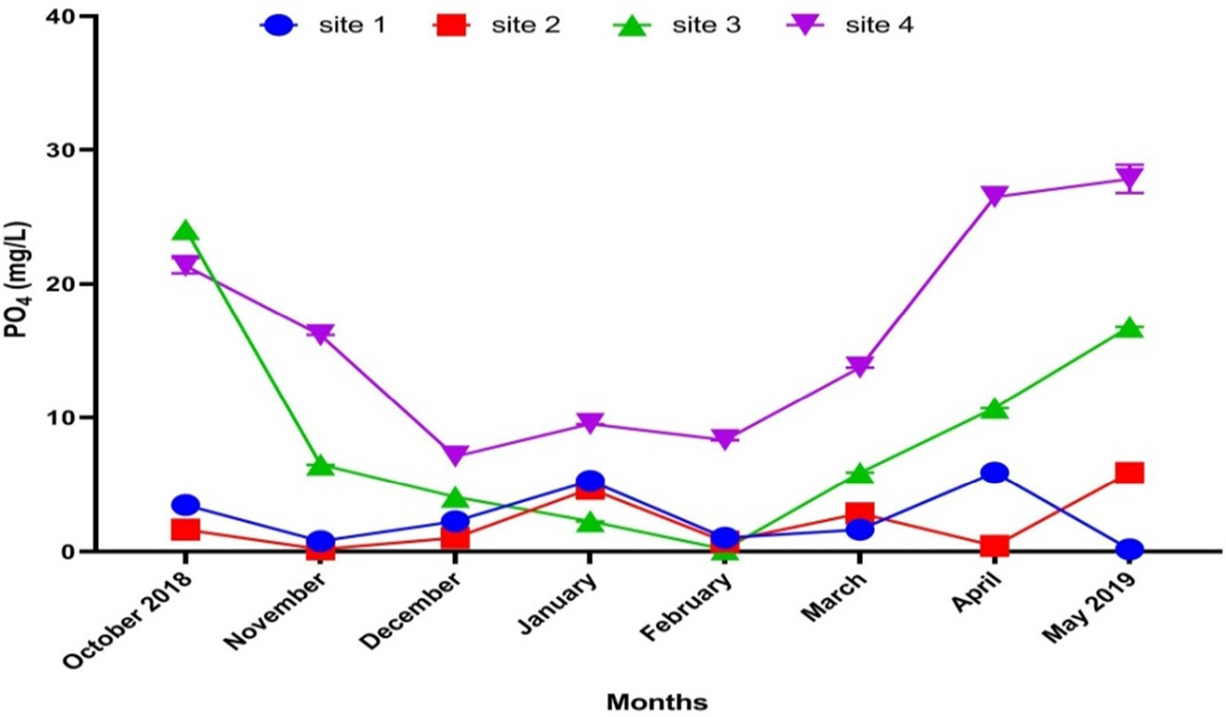

Figure11. Spatio-temporal variations of Phosphate of sulaimani wastewater

Qualitative and Quantitative study of phytoplankton

A total of 114 identified algal taxa during the studied period from all selected sites were listed in (Table 3), belonging to 7 Taxonomical divisions: Bacillariophyta was the most dominate with (63taxa) ,4 taxa of them belong to centric diatom and 59 taxa to pinnate diatoms. The highest percentage of diatoms was recorded at St.2 making up (92.74%) followed by (24 taxa) of Cyanophyta which make up,(90.18%) at St.4 , Chlorophyta, (22 taxa) making up(19.52%) at site3. Two taxa for Pyrophyta and (1 taxa) for each of Euglenophyta , Rhodophyta and Xanthophyta were recorded during the entire study.

Results of phytoplankton density during the period of this study was recorded the highest phytoplankton density 58269.44ind×10^3/L at site4, followed by (22307.7ind×10^3/L) at site 3, and (21274.2ind×10^3/L) at Site 1. The lowest total density(14300.2ind×10^3/L) was recorded at site 2 as shown in Table (3).This variation of Phytoplankton density between sites may be due to the environmental factors and geological formations of the studied area,similar results were observed by [57 , 58]. The highest frequency of *filament blue green algae ,chlorella vulgaris*,*cytclotella ocellata* were (1617.5, 211 and 202) respectivilly which are recorded in site 3,and higest frequency of *Nitzischia palea*(944) recorded at site 1. while the lowest frequency of algae was *composogon sp*.(1) which recorded at sites2 and 3,*surirella angustatum* rate was (1) at site1.

The most dominant species of Bacillariophyceae which identified in all studied sites at most months: Centrales is *Cyclotella ocellata*, while among pinnales order *Achnanthes minutissima, Amphora veneta, Cymbella affinis, Navicula cryptocephala, N. cryptocephala (*var.*veneta)*and *Nitzschia palea.* In the present study the wastewater showed adominant group of diatoms because they are known to be tolerate to avariable number of limnological and environmental factors [59]. Also, their community structure may be responsive to any alterations in the environmental conditions [60,61], many ecological parameters effect on algae growth in the wastewater such as nutrients and temperature, increasing of these parameters lead to increasing of algae growth in wastewaters**.**

Cyanophyceae (24 taxa) formed the second most algal group of phytoplankton at the selected sites, the most abundant species of Cyanophyceae which identified in all studied sites and in most months periods of the study were: *Oscillatoria limnetica, Oscillatoria minima*. Cyanophyta more than any other algae tolerant to organic pollution because they are highly resistant to all sorts of ecological stresses and environmental hardships [62,63].

Chlorophyceae (22taxa) formed the third most algal group at the selected sites, The most abundant species of Chlorophyceae which identified in all studied sites and in most months of study were: *Chlorella sp., Chlorella vulgaris, Coelastrum microporum, Monoraphidium sp., Monoraphidium circinale, Monoraphidium convolutum*. Amongst Chlorophyceae species, *Chlorella vulgaris*. was found to be the most dominant species at all sites. Algal community decreases at all sites during winter, due to unfavorable environmental conditions such as low water temperature , slight sunlight intensity and current oscillation, similar results obtained by [64-69] . Algae genera increasing in October and March may be due to high level of NO_3,PO_4 and temperature during these months, in addition to the increasing of pollutants rate , agricultural runoff , industrial and sewage effluents that discharged in the wastewater.

Table(3) List of phytoplankton identified in the studying sites.(A)=Annual Density (ind.×10^3/L), (B)=Density percentage (%), (C)=Number of frequency, 0=absence

Sites / Taxa	Site one			Site two			Site three			Site four		
	A	**B**	C	**A**	**B**	C	**A**	**B**	C	**A**	**B**	C
CYANOPHYCEAE(Total)	**245.1**	**1.15**		**258**	**1.80**		**13955.4**	**62.5**		**52549.74**	**90.18**	
Aphanothece sp.	0	0	0	0	0	0	51.6	0.23	4	38.7	0.06	3
Chamaesiphon sp.	25.8	0.12	2	12.9	0.09	1	25.8	0.11	2	38.7	0.06	3
*Chroococcus limneticus (*Lemm.)	0	0	0	0	0	0	38.7	0.17	3	0	0	0
Chroococcus turgidus (kutez).Nageli	0	0	0	0	0	0	12.9	0.05	1	25.9	0.04	2
C.dispersus	0	0	0	0	0	0	25.8	0.11	2	0	0	0
Coccoid –blue green algae	12.9	0.06	1	0	0	0	0	0	0	0	0	0
Filament blue-green algae	12.9	0.06	1	12.9	0.09	1	11788.1	52.84	1617.5	51717.44	88.75	858
Lyngbya limnetica(Lemm.)1898	12.9	0.06	1	0	0	0	25.8	0.11	2	12.9	0.02	1
Lyngbya aestuarii(Lemm.)	12.9	0.06	1	25.8	0.18	2	12.9	0.05	1	25.8	0.04	2
Merismopedia convolute(Brebisson)	0	0	0	0	0	0	0	0	0	12.9	0.02	1
M. glauca	0	0	0	0	0	0	12.9	0.05	1	0	0	0
M. tenussima	0	0	0	0	0	0	25.8	0.11	2	12.9	0.02	1
Microcystis aeruginosa(Kutez.)	0	0	0	0	0	0	51.6	0.23	4	0	0	0
Nostoc sp.	12.9	0.06	2	12.9	0.09	2	0	0	0	12.9	0.02	1
Oscillatoria sp.	0	0	0	0	0	0	25.9	0.11	2	12.9	0.02	1
O. amoena	12.9	0.06	1	12.9	0.09	1	0	0	0	0	0	0
O.limnetica (Lemm.)	38.7	0.18	3	64.5	0.45	5	1483.5	6.65	115	258	0.44	25
O.princeps(W.West&G.Swest)	0	0	0	12.9	0.09	1	12.9	0.05	1	25.8	0.04	2
O.terebriform(C.Agardh)	12.9	0.06	1	0	0	0	0	0	0	0	0	0
O.chymlybeum(Mertens)	12.9	0.06	1	12.9	0.09	1	0	0	0	12.9	0.02	1
O. angustissium	12.9	0.06	1	12.9	0.09	1	0	0	0	0	0	0
O.minima(Gicklhom)	64.5	0.30	5	25.8	0.18	2	283.8	1.27	22	335.4	0.57	26
O. amphibium(c.Agardh)	0	0	0	0	0	0	0	0	0	12.9	0.02	1
Spirulina major(Kutez.)	0	0	0	51.6	0.36	4	77.4	0.34	6	38.7	0.06	3
CHLOROPHYCEAE (Total)	**2544.7**	**11.9**		**553.5**	**3.87**		**4354.7**	**19.52**		**2608.2**	**4.47**	
Ankistrodesmus falcatus (Corda)	0	0	0	25.8	0.18	2	0	0	0	25.8	0.04	2
Bultochaete sp.	12.9	0.06	1	0	0	0	0	0	0	0	0	0
Cosmarium hammeri(Reinsch)	12.9	0.06	1	0	0	0	0	0	0	38.7	0.06	3

Chlamydomonas sp.	12.9	0.06	1	0	0	0	0	0	0	1019.1	1.74	79
Chlorella sp.	78.6	0.36	8	38.7	0.27	13	51.6	0.23	43	72.3	0.12	39
C. vulgaris(M.Beijierinck)	1057.8	4.97	82	154.8	1.08	12	2735.3	12.26	211	1046.1	1.79	81
C. aellipsoidea	0	0	0	0	0	0	12.9	0.05	1	0	0	0
Coelastrum microporum(Nageli)	206.4	0.97	16	38.7	0.27	3	38.7	0.17	3	51.6	0.08	4
Closterium sp.	0	0	0	0	0	0	12.9	0.05	1	12.9	0.02	1
Cosmarium hammeri(Reinsch)	12.9	0.06	1	0	0	0	0	0	0	38.7	0.06	3
Crucigenia tetrapedia(Kircher)	0	0	0	0	0	0	0	0	0	12.9	0.02	1
Kirchneiella obesa	12.9	0.06	1	12.9	0.09	1	12.9	0.05	1	0	0	0
Pandorina morum	0	0	0	0	0	0	12.9	0.05	1	0	0	0
Scendesmus sp.	12.9	0.06	3	12.9	0.09	3	12.9	0.05	7	12.9	0.02	8
S. acuminatus	0	0	0	12.9	0.09	1	0	0	0	0	0	0
S. bijuga	0	0	0	0	0	0	12.9	0.05	1	12.9	0.02	1
S. quadricauda(Chodat)	0	0	0	25.8	0.18	2	25.8	0.11	2	0	0	0
Tetramedron minimum(A.Braun)Hansgrig	25.8	0.12	2	12.9	0.09	1	0	0	0	51.6	0.08	4
Monoraphidium sp.	1002	4.70	60	122	0.85	34	1254	5.62	19	116	0.19	20
M.circinale	58	0.27	11	67	0.46	8	58	0.25	33	38.7	0.06	8
M.convolutum	38.7	0.18	4	29.1	0.20	3	101	0.45	66	58	0.09	11
Oedogonium sp.	0	0	0	0	0	0	12.9	0.05	1	0	0	0
EUGLENOPHYCEAE (Total)	**335.4**	**1.57**		**64.5**	**0.45**		**38.7**	**0.17**		**51.6**	**0.08**	
Euglena sp.	335.4	1.57	25	64.5	0.45	5	38.7	0.17	3	51.6	0.08	4
PYROPHYCEAE (Total)	**141.9**	**0.66**		**90.3**	**0.63**		**90.3**	**0.40**		**77.4**	**0.13**	
Peridinium cinctum(Muller)	141.9	0.66	11	90.3	0.63	7	90.3	0.40	7	77.4	0.13	7
Dinobryon sertularia	0	0	0	25.8	0.18	2	0	0	0	0	0	0
RODOPHYCEAE (Total)	**0**	**0**		**12.9**	**0.09**		**12.9**	0.05		**0**	**0**	
Composogon sp.	0	0	0	12.9	0.09	1	12.9	0.05	1	0	0	0
XANTHOPHYCEAE(Total)	**77.4**	0.36		**58.7**	**0.41**		**12.9**	**0.05**		**38.7**	**0.06**	
Tribonema sp.	77.4	0.36	6	58.7	0.41	33	12.9	0.05	3	38.7	0.06	18
BACILLAROPHYCEAE (Total)	**17929.7**	**84.27**		**13262.3**	**92.74**		**3842.8**	**17.22**		**2943.8**	**5.05**	
A- CENTERALES	**732.5**	**3.44**		**754**	**5.27**		**3016.3**	**13.52**		**2146**	**3.68**	
Aulacoseira granulate (Ehr.)1979	29	0.13	2	0	0	0	0	0	0	14.5	0.02	1
Cyclotella ocellata(Pant)1902	689	3.23	45	754	5.27	34	2929.3	13.13	202	2117	3.63	146
C. meneghiniana(Kutez.)1844	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Melosira granulata(Ehr.)	0	0	0	0	0	0	87	0.38	6	14.5	0.02	1

B-PENNALES	**17197.2**	**80.83**		**12508.3**	**87.46**		**826.5**	**3.70**		**797.8**	**1.36**	
Achnanthes sp.	0	0	0	0	0	0	14.5	0.06	1	0	0	0
A. celevi	14.5	0.06	1	14.5	0.10	1	0	0	0	0	0	0
A. minutissima(Kutz.)1833	594	2.79	41	14.5	0.10	1	58	0.25	4	43.5	0.07	3
Anomoeoneis exilis(Kutez.)	58	0.27	4	0	0	0	0	0	0	0	0	0
Anomoeoneis sphaerophora	29	0.13	2	14.5		1	0	0	0	0	0	0
Amphora coffeaeformis (c.Agardh)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
A. veneta(Kutz.)	58	0.27	4	58	0.40	4	14.5	0.06	1	72.8	0.12	5
Bacillaria paxillfer(Mull.) 1951	0	0	0	14.5	0.10	1	0	0	0	0	0	0
Caloneis sp.	0	0	0	14.5	0.10	1	14.5	0.06	1	14.5	0.02	1
Caloneis bacillum	14.5	0.06	1	14.5	0.10	1	0	0	0	0	0	0
Cocconeis placentula (Ehr.)1838	29	0.13	2	0	0	0	0	0	0	0	0	0
C. pediculus (Ehr.)	0	0	0	0	0	0	0	0	0	14.5	0.02	1
C. placentula(var.euglypta) 1844	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Cymbella affinis(Kutz.)	14.5	0.06	1	58	0.40	4	29	0.12	2	29	0.04	2
C. cistula(Ehr.)	0	0	0	0	0	0	0	0	0	14.5	0.02	1
C. helvetica (kutez)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
C. ventricosa(C.Agardh)	0	0	0	14.5	0.10	1	0	0	0	29	0.04	2
C. microcephala(Grun)1880	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Diatoma vulgare (Bory.) 1824	29	0.13	2	0	0	0	14.5	0.06	1	43.5	0.07	3
D. elangatum(Agardh.)	0	0	0	0	0	0	0	0	0	14.5	0.02	1
Diploneis ovalis(Hilse)1894	0	0	0	14.5	0.10	1	0	0	0	0	0	0
Epitheca sorex	0	0	0	0	0	0	14.5	0.06	1	0	0	0
Fragillaria acus (Kutez)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
F. ulna (Nitz.)	72.5	0.34	5	101.5	0.70	6	14.5	0.06	1	14.5	0.02	1
F. ulna (var.biceps)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
F. ulna(var.oxyhrynchus)	29	0.13	2	58	0.40	3	14.5	0.06	1	0	0	0
F. fasciculata	29	0.13	2	14.5	0.10	1	0	0	0	0	0	0
F. vaucheriae (Kutez.)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Gomphonema angustatum (Kutez.)Rabh	58	0.27	4	80.8	0.56	5	58	0.25	4	0	0	0
G.lurris(Ehr.)	14.5	0.06	1	14.5	0.10	1	0	0	0	0	0	0
G. olivaceum (Lyngb.)	0	0	0	14.5	0.10	1	0	0	0	0	0	0
G. parvulum(Kutez.)	0	0	0	29	0.20	2	0	0	0	0	0	0
G. sphaerophorum(Ehr.)	0	0	0	14.5	0.10	1	0	0	0	0	0	0

Gyrosigma scalproides	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Hantzschia amphioxys(Ehr.)1880	29	0.13	2	29	0.20	2	58	0.25	3	58	0.09	4
Navicula cryptocephala (Kutz.)	261	1.22	18	377	2.63	24	130.5	0.58	9	72.5	0.12	5
N. cryptocephala var intermedia(Grun)	0	0	0	14.5	0.10	1	0	0	0	0	0	0
N. cryptocephala (var.veneta)	29	0.13	2	43.5	0.10	3	43.5	0.19	3	43.5	0.07	3
N. gracilis(Ehr.)	0	0	0	14.5	0.10	1	0	0	0	0	0	0
N.pygmea(Kutz.)1849	14.5	0.06	1	0	0	0	0	0	0	0	0	0
N. radiosa	0	0	0	14.5	0.10	1	0	0	0	0	0	0
Nitzschia sp.	14.5	0.06	1	14.5	0.10	1	14.5	0.06	1	14.5	0.02	1
N. amphibia (Grun)	29	0.13	2	0	0	0	0	0	0	0	0	0
N. apiculata	14.5	0.06	1	29	0.20	2	0	0	0	0	0	0
N. acicularis	1551.5	7.29	107	217.5	1.52	15	29	0.12	2	14.5	0.02	1
N. hungarica(Grun.) 1862	101.5	0.47	7	29	0.20	2	0	0	0	0	0	0
N. palea(kutz.)	13717.7	64.48	944	11021	77.06	139	232	1.03	44	159.5	0.27	11
N.sigma	0	0	0	0	0	0	0	0	0	29	0.04	2
N.sigmoidea(Ehr.)	14.5	0.06	1	29	0.20	2	14.5	0.06	1	29	0.04	2
N.dubia(W.smith)	0	0	0	14.5	0.10	1	0	0	0	0	0	0
N. dissipata(Grun.)	58	0.27	4	0	0	0	43.5	0.19	3	0	0	0
N. frustulum(Kutz.)	29	0.13	2	14.5	0.10	1	0	0	0	0	0	0
N. gracilis(Hantzch.)	14.5	0.06	1	0	0	0	0	0	0	0	0	0
N. longissima(Breb.)	14.5	0.06	1	0	0	0	0	0	0	14.5	0.02	1
N. microcephala	0	0	0	29	0.20	2	0	0	0	0	0	0
N. tryblionella(Hantzsch)	0	0	0	0	0	0	0	0	0	14.5	0.02	1
Rhoicosphenia curvata(Kutez.)	101.5	0.47	7	0	0	0	0	0	0	14.5	0.02	1
Surirella ovata(Kutez.)1844	29	0.13	2	58	0.40	4	14.5	0.06	1	43.5	0.07	3
S. angustatum	14.5	0.06	1	0	0	0	0	0	0	0	0	0
Total Density(ind.× 10^3/L)	**21274.2**			**14300.2**			**22307.7**			**58269.44**		

Conclusion

Decreasing of dissolved oxygen and increasing in BOD_5, EC and TDS indicates that the wastewater highly polluted by industrial and domestic waste from the area near the studied sites .Diatoms was the most dominant group of phytoplankton in sulaimani wastewater and high density of algal population was related to the increasing of nutrients level in the studied sites.

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