The effect of wastewater disposal on the water quality and phytoplankton in Erbil wastewater channel.

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Date of acceptance 6/5/2009

Abstract

In this study, phytoplankton density, chlorophyll-*a*, and selected physico-chemical parameters were investigated in Erbil wastewater channel. The surveys were carried out monthly from May 2003 to April 2004. Samplings were established on three sites from headwaters to the mouth. The results showed that pH was in alkaline side of neutrality, with significant differences ($P<0.05$) between sites 1 and 3. TSS concentration decreased from site 1 toward site 2 (mean value, 80.15 to 25.79 $mg.l^{-1}$). A clear gradual increase in mineral content (TDS) observed from site one of the channel towards the mouthpart. Soluble reactive phosphate has a concentration maximum mean value reached 48.4 $\mu g.l^{-1}$ which is recorded in site 2. A high positive relationship ($P<0.01$, $r=0.449$) obtained between phosphate concentration and phytoplankton density. The results of chlorophyll-*a* concentration were (mean values, 2.26, 3.88 and 2.42 $\mu g.l^{-1}$ respectively), showed the positive relationship ($P<0.05$, $r=0.012$) with phytoplankton density.

The PCA produced three significant main components which represented by more than 64.5% of the total variance, namely, nutrients related to algal productivity; disposal wastewater and storm water runoff, in which explained by 31.29, 19.68 and 13.55% respectively of the total variance of water quality in polluted channel.

Key words: Wastewater, water quality, degradation, nutrients, Phytoplankton.

Introduction:

Physical, chemical and biological parameters are important characters to recognized wastewater quality [1]. Pollutants entering water system normally results from many transport pathways including stormwater runoff, discharges from untreated wastewater and atmospheric deposition [2]. Non-point source nutrients enrichment has became a dominant source of water quality impairment throughout the world [3].

Erbil wastewater composes of domestic sewage, industrial wastewater and stormwater [4]. This channel extended from southwest of Erbil city with their elongation for more than 50 Km passes through vast farmlands, orchards and several villages till its effluent discharges into Greater Zab river [5]. The channel dimension varied from place to other but generally it ranged from 2- 3.5m width and 0.5- 1.5m depth [6 and 7]. Their quantity discharge ranges from 0.85 m^3/S to 1.7 m^3/S measured in former part of channel, farmer families along polluted channel depend mainly on untreated wastewater for their field irrigation, especially during dry season. Vegetables are the main crops in these villages. Only in Arab- Kand village

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the farmers irrigate about 520 hectares of agriculture land [8]. According to [9] domestic sewage consist of approximately 99.9% water, 0.02-0.03% suspended solids, and other soluble organic and inorganic substances. Degradation of water quality due to organic and inorganic contaminants has resulted in altered aquatic biota in their quality and quantity [10 and 11]. The change in the phytoplankton community structure can be particularly useful as an assessment tool, due to their response to environmental stress [12 and 13].

Despite the large number of researches available on the spatial and temporal variation in phytoplankton density and community structure in lakes and rivers, little information is available on the phytoplankton density variation in polluted water [14]. Many studies have been focused on water quality of Erbil wastewater channel for hygienic status and agricultural purposes such as [5, 7, 15, 16 and 17]. As well as, studies of (6 and 19) deal with algal community structure and indices.

The objective of this work is to analyze the biological (phytoplankton density and chlorophyll *a* content) and physico- chemical properties of heavily polluted wastewater channel to get a better understanding of these influences to water quality.

Materials and Methods:

Samples were taken from three monitoring sites. Arab-Kand village (site 1); Abassyia village (site 2), and Kudara village (site 3) on the Erbil wastewater channel at regular monthly intervals from May 2003 to April 2004 (Figure1). Water samples were collected from the surface. Water temperature measured by using mercury thermometer; pH by using pH meter (Philips 9420). Sub samples were taken for nutrients analysis by filtration through Whatman GF/C filter. Nutrients were measured by following methods: soluble reactive phosphate (SRP, phosphomolybdate – Ascorbic acid reduction) and silicate (SiO_2) by acid- molybdate reduction [19]. While for total suspended solids(TSS) water samples were filtered through GF/C filter(pre-weighed glass filters dried at 105 °C and weighed); total dissolved solids (TDS, evaporation of filtered water at 180 °C and weighed dish); and volatile solids (VS), filters combusted at 550 °C for 5 hours and weighed [20].

The chlorophyll-*a* concentration of prepared samples was determined spectrophotometrically using the cold acetone extraction method [21]. Meanwhile, phytoplankton enumeration was determined by using filtration method as described by [22].

Physico- chemical factors; nutrient concentrations, chlorophyll-*a* concentration and phytoplankton density were compared statistically by using one way analysis of variance (ANOVA). Duncan test was used to examine multiple comparisons. Correlation was evaluated for significance using a Pearson product moment correlation test procedure. Principal component analysis (PCA) was performed to relate phytoplankton density and chlorophyll-*a* density to a biotic variables using (SPSS version 15) program [23].

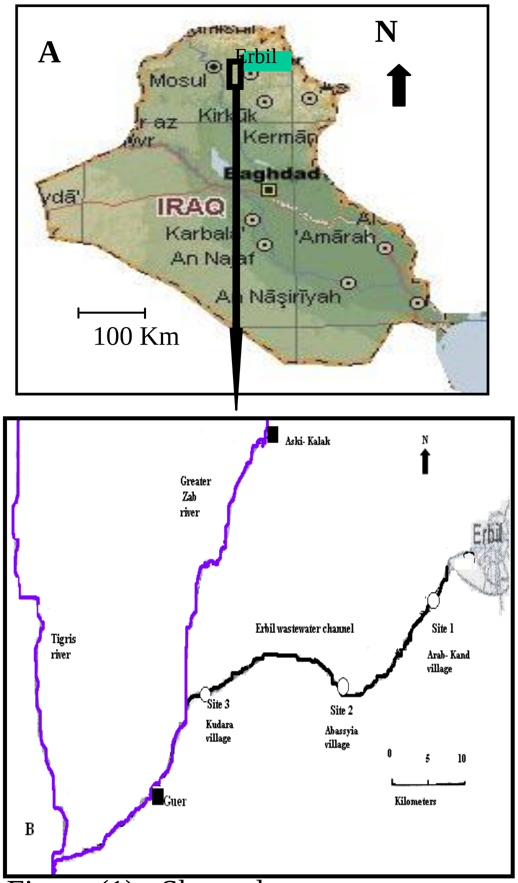

Figure (1): Showed:
A- Map of Iraq with selected studied area.
B- Erbil wastewater channel studied sites.

Results and Discussion:

During the period of study, fluctuation of environmental parameters in the examined surface water samples at the various monitoring sites were summarized in Table (1), as mean± standard error (SE). The pH values at all sites in the channel were found to be in alkaline side of neutrality, with highest mean value recorded in site 3 (Figure 2). This may be due to sewage disposal loaded with high concentration of alkaline nature detergents [15, 16, 24 and 25]. A clear gradual increase in pH value observed from site 1 towards site 3. Statistically significant differences ($P<0.05$) found between sites 1 and 3. Such phenomenon was noted by [5, 7 and 18] in the same channel and they return the reason to the self purification process.

The total suspended solids (TSS) are particles of different materials that suspended in water. Moreover, provides adsorption sites for chemicals and biological agent [26]. High TSS value recorded in site 1 with mean value reached 80.15 mg.l^{-1}, then decreased in site 2 with gradual increase towards site 3. Significant difference ($P<0.05$) was observed between sites 1 and 2 (Figure 3). [27] Commented that increase in suspended solids and particles in wastewater could be returned to the content of the organic materials, phosphorus and sometimes nitrogen that discharged from effluent sludge.

Total dissolved solids (TDS) originated from natural sources, sewage effluent discharges, urban runoff, or industrial waste discharge [26].

The study revealed that an increase in mineralization toward downstream of channel with highest mean value at site 3 reached 896.2 mg.l^{-1}. A high TDS implies that the water has a high concentration of mineral salts which might come from land runoff, or accumulation of salt ions due to increasing distance from their sources [28]. No significant differences ($P<0.05$) observed between studies sites. On the other hand, lowest volatile solid (VS) content recorded in site 3 (mean value, 194.5 mg.l^{-1}), while highest value observed in site 2. Statistically no significant differences ($P<0.05$) found between studied sites (Table 1).

Domestic wastewaters, particularly those containing detergents, industrial effluents and fertilizer runoff contribute to elevate the levels of phosphates in surface waters [29]. The highest phosphate levels were observed at site 2 (mean, 48.4 µg PO_4- $P.l^{-1}$) in comparison to other sites (Table 1). The hydrolysis of polyphosphates and reverts to the orthophosphate forms is the main source of phosphate in polluted channel [30 and 31].

Generally, silicate concentrations were relatively high during studied period. The minimum and maximum value ranged between 129.6 – 353.5 µg SiO_2- Si. l^{-1} recorded at site 1 during May and site 3 during April respectively. No significant differences ($P<0.05$) were observed between studied sites. This results agree with results of [4], while they were higher than that of [6, 7 and 18] at Erbil wastewater channel and [32] in Sulaimanyia sewagewater.

Chlorophyll-*a* is one of the most commonly used biological measurements in water quality monitoring and assessment, particularly in relation to the effects of increasing nutrients or in relation to the operation of water treatment process [29]. During the studied period, chlorophyll-*a* concentration was under 7.7 $\mu g.l^{-1}$ except in one occasion, 11.7 $\mu g.l^{-1}$ recorded during May in site 2 Figure, 4). This could be due to high phytoplankton density.

Phytoplankton density regarded as productivity indicator in aquatic ecosystems increased with nutrients supplement [33]. Phytoplankton density varied from studied sites 1, 2 and 3 with mean values (21787, 18773 and 21631 $cells.l^{-1}$) respectively. [6] Found that phytoplankton numbers ranged from 407 to 2556 $cells.l^{-1}$, with two peaks recorded.

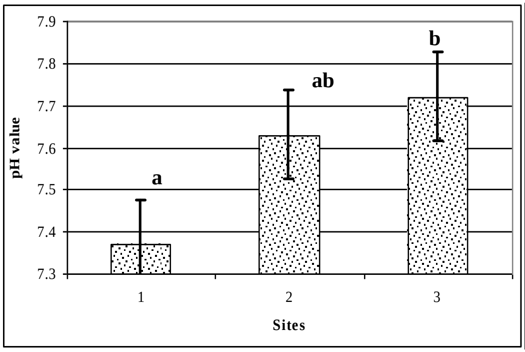

Figure (2): Variation of pH value in Erbil wastewater channel sites. Values are shown as mean ±

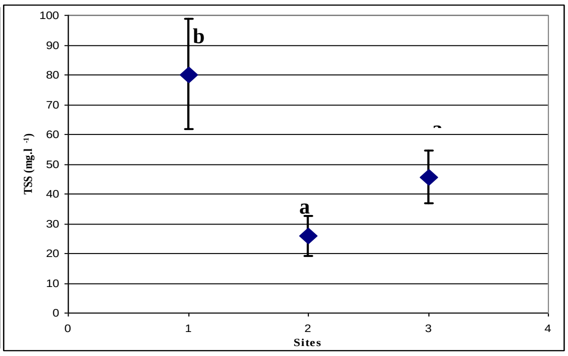

Figure (3): Variation of total suspended solid in Erbil wastewater channel sites. Values shown as mean ± standard

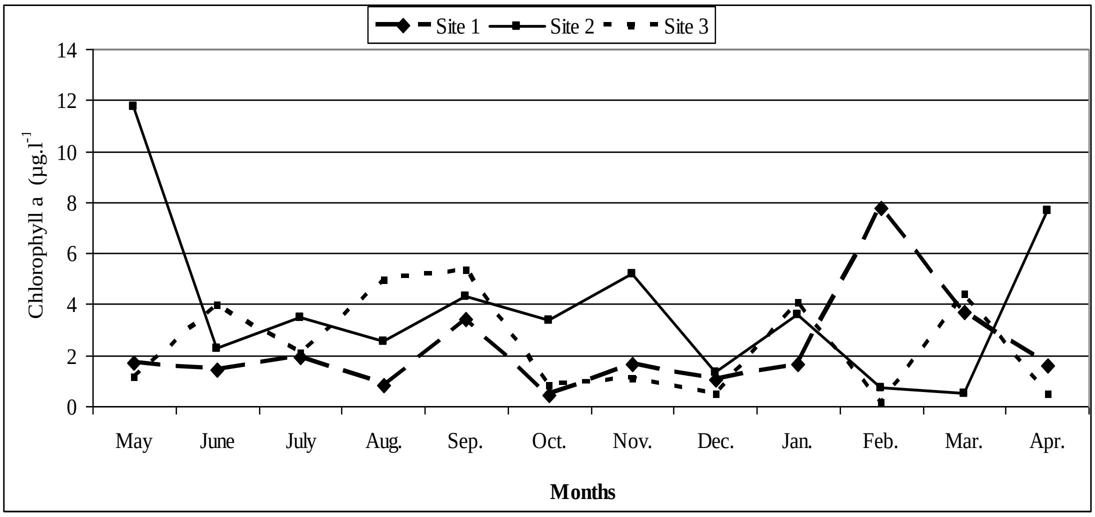

Figure (4): Monthly variation of chlorophyll *a* concentration ($\mu g.l^{-1}$) in Erbil wastewater channel sites.

Table (1): Physical-chemical properties of Erbil wastewater channel, data represented as mean ± SE.

Sites	1	2	3
pH	7.73± 0.106 [a]	7.63± 0.102 [ab]	7.72± 0.113 [b]
TSS ($mg.l^{-1}$)	80.15 ± 18.5 [b]	25.79 ± 12.71 [a]	45.6 ± 10.96 [ab]
TDS ($mg.l^{-1}$)	354.49 ± 39.5 [a]	374.9 ± 43.3 [a]	896.2 ± 552.6 [a]
VS ($mg.l^{-1}$)	206.8 ± 21.26 [a]	207.7 ± 25.65 [a]	194.5 ± 22.03 [a]
PO_4 ($\mu g\ PO_4$-$P.l^{-1}$)	38.39 ± 4.33 [a]	48.4 ± 3.59 [a]	42.2 ± 4.77 [a]
SiO_2 ($\mu g\ SiO_2$-$Si.l^{-1}$)	276.7 ± 16.58 [a]	285.1 ± 13.35[a]	263.6 ± 15.6 [a]
Phytoplankton density ($Cells.l^{-1}$)	21787.5 ± 10764.1 [a]	18773.6 ± 7853.9 [a]	21631.98 ± 7952.2 [a]
Chlorophyll *a* ($\mu g.l^{-1}$)	2.26 ± 0.56 [a]	3.88 ± 0.91 [a]	2.42 ± 0.56 [a]

***Note*: Values in each rows with different letters are significantly different at P<0.05. Values in rows with same letters are not significantly different.**

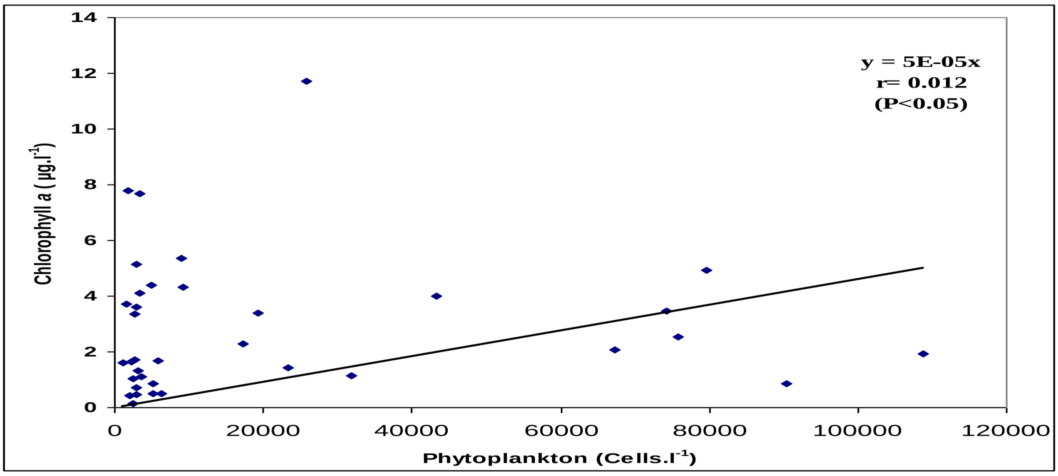

Figure (5): Relationship between phytoplankton density and chlorophyll- *a* concentration.

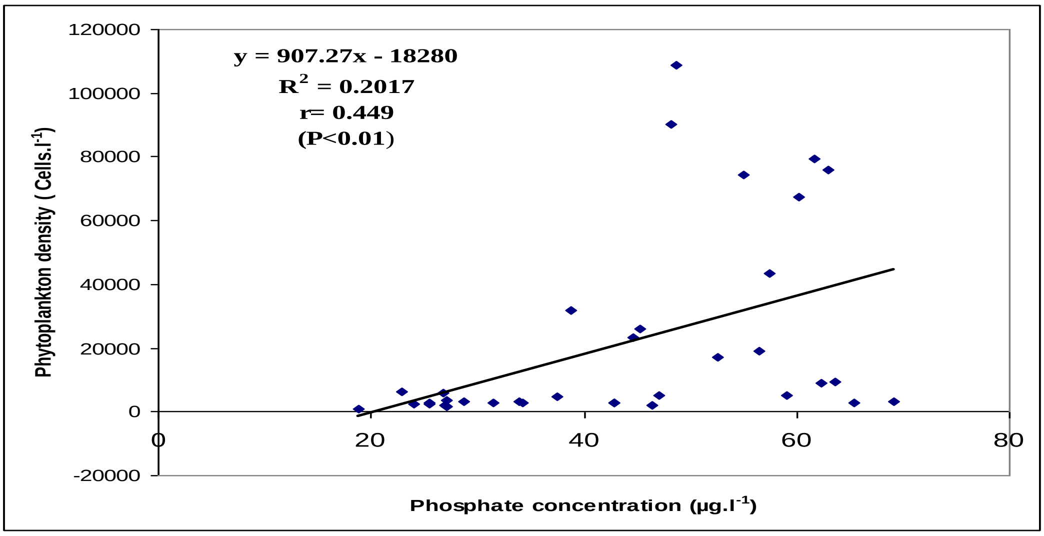

Figure (6): Relationship between phytoplankton density and phosphate concentration.

during October and March 2001 In the same channel, and he stated that Erbil wastewater channel is very poor in productivity. A positive relationship ($P<0.05$, r =0.012) recorded between chlorophyll-*a* and phytoplankton density (Figure 5), in addition to its positive relationship ($P<0.01$, r =0.449) with phosphate concentration (Figure, 6). This suggests that phosphorus may be the element for controlling algal growth [13]. [34] Reported that a nutrient such as phosphorus leads to an increase in algal growth and causes algal blooms. This came in accordance with results of [35] in their study on Greater Zab River.

Principal component analysis (PCA) is multivariate statistical analysis used to identify important components that explain most of the variances of a system. They are designed to reduce the number of variables to a small number of indices, while attempting to preserve the relationships present in the original data [36 and 37]. The correlation matrix of the eight analyzed water quality variables were calculated from data normalized as shown in Table (2).

The first three factors each have an eigenvalue >1, and together account for nearly 65% of the observed variation in water quality observations. The first factor (PC_1) contains PO_4, SiO_2, phytoplankton density and chlorophyll *a* concentration with high and positive correlation. These nutrients are responsible for increasing productivity in these aquatic ecosystems [38, 39 and 40]. The second factor (PC_2) incorporates those water quality variables that are characteristic of wastewater discharges, including TDS, VS, PO_4, as well as, phytoplankton density [41]. The third factor (PC_3) account for 13.55% of the total variance in wastewater channel, this component is positively correlated with TSS which could be used as indicator of storm water runoff [42]; meanwhile, pH has a negative loading to water quality. These results were graphically represented in Figures [7 and 8].

Table (2): Eigenvalue and percentage of variance explained by each of the four principal components (PCs) for Erbil wastewater channel studied variables.

Principal Component	**PC_1**	**PC_2**	**PC_3**
Eigenvalue	**2.503**	**1.575**	**1.083**
% total variance explained	**31.29**	**19.68**	**13.55**
% cumulative variance	**31.29**	**50.97**	**64.53**
Rotated factor correlation coefficients			
pH	**-0.461**	**-0.146**	**-0.716**
TSS	**-0.082**	**-0.069**	**0.836**
TDS	**0.037**	**0.772**	**0.227**
VS	**0.144**	**0.770**	**0.189**
PO_4	**0.760**	**0.317**	**-0.017**
SiO_2	**0.782**	**-0.158**	**0.133**
Phytoplankton density	**0.547**	**0.700**	**-0.029**
Chlorophyll *a*	**0.530**	**-0.020**	**0.050**

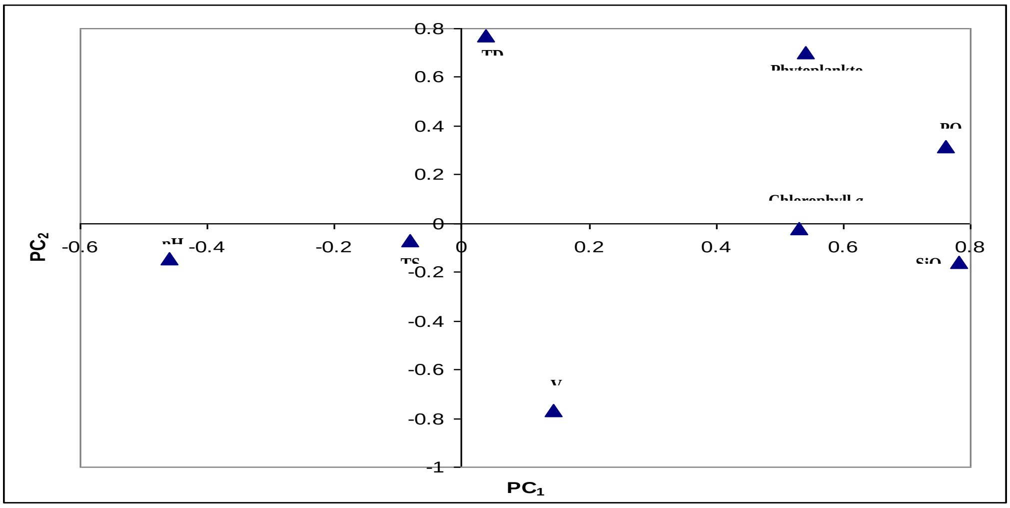

Figure (7): Principal component analysis (PCA) scatterplot for Erbil wastewater channel samples on the basis of studied variable characteristics.

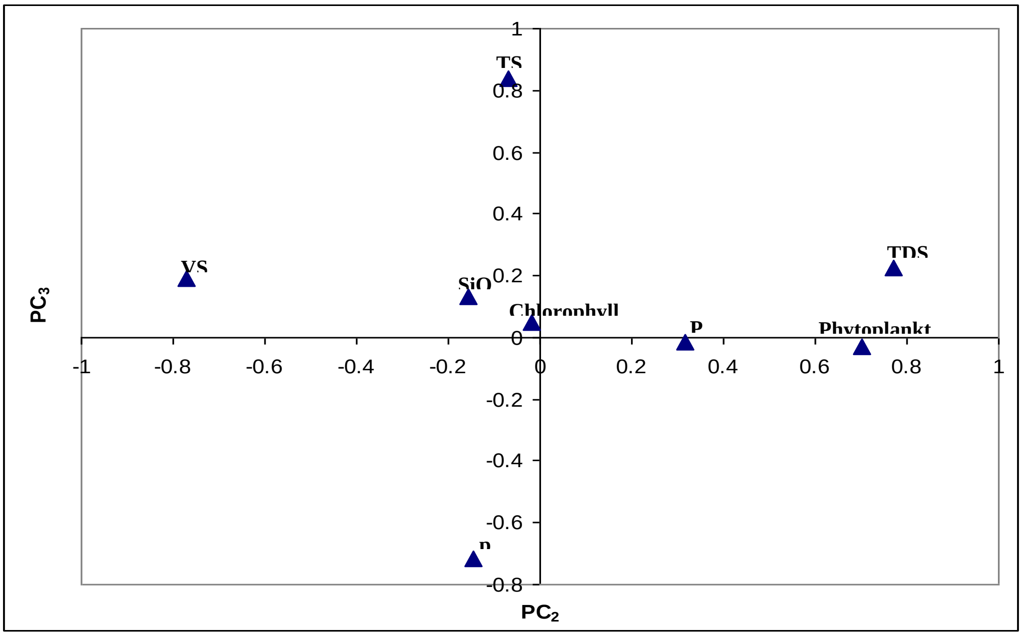

Figure (8): Principal component analysis (PCA) scatterplot for Erbil wastewater channel samples on the basis of studied variable characteristics.

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تأثير تصريف الفضلات في نوعية المياه وكثافة الهائمات في قناة مجاري اربيل

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الخلاصة

تمت في هذه الدراسة فحص كثافة الهائمات النباتية وكلوروفيل أ وبعض العوامل الفيزيائية والكيميائية المختارة في قناة مجاري اربيل. وتم مسح القناة شهريا" وباختيار ثلاث مواقع للدراسة على طول المجرى ولمدة سنة كاملة (ايار 2003 لغاية نيسان 2004).

اظهرت النتائج بان قيم الرقم الهيدروجيني كانت تميل الى الجانب القاعدي وسجل فرق معنوي ($P<0.05$) بين المحطتين رقم 1 و 3. وانخفضت تراكيز المواد العالقة كلما اتجهنا من المحطة الاولى باتجاه المحطة الثانية بمعدل 80.15 الى 25.79 ملغم/لتر. بينما لوحظ زيادة تدريجية في المحتوى الملحي (المواد الذائبة الكلية, TDS) في بداية القناة نحو النهاية. بلغ اعلى تركيز للفوسفات المذاب النشط 48.4 مايكروغرام . لتر$^{-1}$ في المحطة الثانية, كما وجدت علاقة ارتباط معنوية عالية ($P<0.05$, $r= 0.449$) بين تركيز الفوسفات وكثافة الهائمات النباتية. من جهة اخرى بلغ معدل تركيز الكلوروفيل أ في المواقع الثلاثة 2.26 و 3.88و 2.24 مايكروغرام . لتر$^{-1}$ على الترتيب. فضلا عن وجود علاقة ايجابية ($P<0.05$, $r = 0.012$) في تركيز الكلوروفيل أ مع الهائمات النباتية.

تحليل المكونات الرئيسة (PCA) نتجت عنه ثلاث مكونات معنوية ذات تمثيل بلغ اكثر من 64.5% من قيمة المتغيرات والعوامل التي اثرت في نوعية المياه في القناة وتمثلت في المغذيات المرتبطة بانتاجية الطحالب وتصريف فضلات المجاري وانجراف المواد بفعل مياه الامطار, اذ بلغ معدل المتغيرات الكلية لنوعية المياه بنسبة 31.29و 19.68 و 13.55% على الترتيب.