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Investigation on Nutrient Behavior Along Shatt Al-Arab River, Basrah, Iraq

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ABSTRACT

Shatt Al-Arab River is the main vital water resource in southern Iraq. Changes have come about in the last few years which could results in alteration in water characteristics of the river, among which are nutrients. Undersurface water samples were collected from ten stations along Shatt Al-Arab River during the period October 2009 to September 2010. The present study has revealed that range of nitrite and nitrate concentrations were 0.1to 9.88 and 4.4 to 43.9µg-at.N/l respectively. Variation in phosphate concentration was between 0.76 and 12.48µg-at.P/l, whereas the minimum and maximum silicate concentrations were 15.9 and 76.7 µg-at.SiO_2/l. Downstream stations showed higher nutrients concentration compared to upstream stations because they are more impacted by pollutant from both diffuse and point sources. Climatic changes as well as reduction in water income to the river have resulted in alteration in nutrients concentration. The river water is eutrophicated and load of nutrients to coastal area might results in high growth of primary producers.

Key words: Nutrient Concentration, Upstream and Downstream Stations, Eutrophication, Basrah.

Introduction

Nutrients are probably the most essential material in aquatic ecosystems because their dynamics can limit primary production and heterotrophic activities. Nutrient dynamics affect ecosystem production and the interaction among environment, autotrophs and heterotrophs. The balance between utilization of nutrients and remineralization is the basis that nutrient concentrations are moderately stable in short term (Dodds, 1993).

Factors altering nutrient availability in aquatic ecosystems are chemical characteristics, geology, and human land use. Dissolved inorganic phosphate, nitrogen and silica are usually considered the most critical nutrients for algal production, although other chemical elements can also limit their growth under some circumstances (Wetzel, 2001). However, algae can directly utilize some of these nutrients in dissolved organic forms (Berman and Chava, 1999).

The demand for certain nutrients, especially phosphor and nitrogen, is usually much greater than their supply in different aquatic systems. However, human activities have profoundly change nitrogen and phosphor dynamics by increasing their availability in aquatic systems, resulting in eutrophication of lakes, rivers, and coastal environments worldwide (Carpenter *et al.,* 1998). From water quality point of view, the concern about eutrophication is usually due to cultural eutrophication. Increased input of nutrients could be due to leaching from fertilizers used in agriculture, storm runoff from urbanized land, industrial waste, watershed disturbance, and direct discharge of treated and untreated sewage into aquatic ecosystems (Wetzel, 2001). Eutrophication of coastal areas is considered a globally growing challenge, though water of these environments is impacted by transport of large quantities of nutrients by river waters which results in degradation of water quality of costal environments (Rabalais *et al.,* 1996).

A number of ecological studies have been executed on the water of Shatt Al-Arab River since the seventies of the last century (Hameed, 1977; Al-Asadi, 1983; Al-Shawi *et al.,* 2005). However, changes havecome about in the last few years which could results in alteration in water characteristics of the river. The objectives of this study was to evaluate seasonal and spatial changes in nutrient concentration along Shatt Al-Arab River waterway, to discuss the reasons responsible for these changes and the ecological implications of nutrients concentration increase on coastal area.

Materials and methods

Study Area:

Shatt Al-Arab Riveris formed by the confluence of Tigris- and Euphrates rivers north of Basrah at Qurna (Fig.1). The river flow southeasterly and enter the Arabian Gulf south of Al-Fao city. Three tributaries flow into

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the river, Al-Seweb River which is connected at 15 km south of Qurna, Garmat Ali River that drains AlhammarMarsh, and Karun River which flow through the Iranian territory and discharge its water in Shatt Al-Arab River, 35 km downstream of Basrah.

Fig. 1: Map of Shatt Al-Arab River and Sampling Locations.

The water in Al-Seweb and Garmat Ali tributaries has been reduced in the last few years (Al-Mansory, 1996). Moreover, the diversion of Karun River towards the Iranian side was put in practice during 2009.A number of drinking water treatment facilities are situated along the main channel of the river. The Shatt Al-Arab River is subjected to diurnal tidal fluctuations and is affected by busy water traffic and impacted by disposal of untreated waste from different sources. The catchment area of the river is mainly agricultural and rural in the upstream while densely populated as well as agricultural fields, especially date palms are the main components of downstream catchment area.

Field and Laboratory Analysis:

During the period October, 2009 to September, 2010 ten stations (1-6 upstream- and 7-10 downstream stations) along Shatt al-Arab River main basin were sampled (Fig.1). Water sampler was used to collect under surface water samples for chemical analysis and samples weretransported to laboratory in a cool box. Water for nutrient analysis (nitrite, nitrate, phosphate, and silicate) were filtered upon arrival in the laboratory using GFC filter papers and analyzed as soon as possible according to Parsons *et al.*, (1984).

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Statistical Analysis:

Analysis of variance was calculated for seasonal and spatial changes in nutrient concentration and correlation between nutrients was also calculated using SPSS 10.

Results and discussions

Nitrite-nitrogen and nitrate-nitrogen concentrations ranged from 0.1to 9.88 µg-at.N/l and 4.4 to 43.9 µg-at.N/l respectively. Variation in phosphate concentration was between 0.76 and 12.48 µg-at.P/l, whereas the minimum and maximum silicate concentrations were 15.9 and 76.7 µg-at.SiO_2/l. The highest concentrations of nitrite and nitratewere measured during November 2009, whereas the lowest concentrations were recorded during July 2010 and March-April 2010 for nitrite and nitrate respectively (Fig. 2 and 3). Nitrate concentrations steadily increased from April onwards. Figure (4) highlights seasonal variation in phosphate concentration, though the concentration dropped to low levels during March-April 2010, then after increased towards summer. Although the pattern of silicate was not consistent among stations, however silicate concentrations were low during April-May 2010.

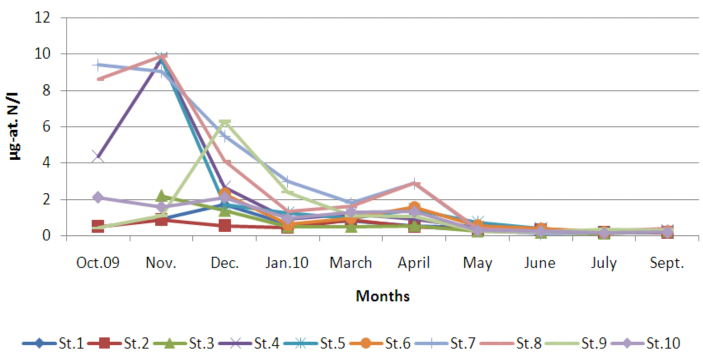

Fig. 2: Variation in nitrite-nitrogen concentration of Shatt Al-Arab River.

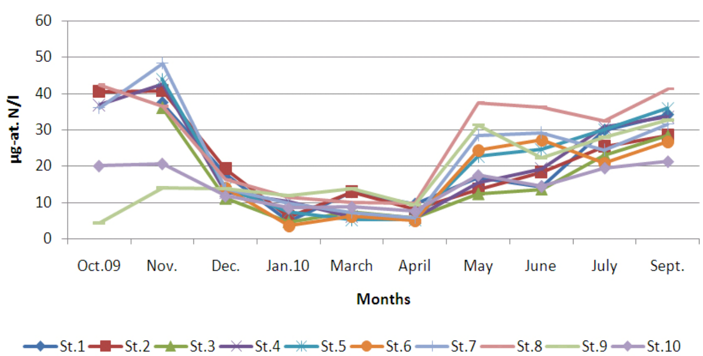

Fig. 3: Variation in nitrate-nitrogen concentration of Shatt Al-Arab River.

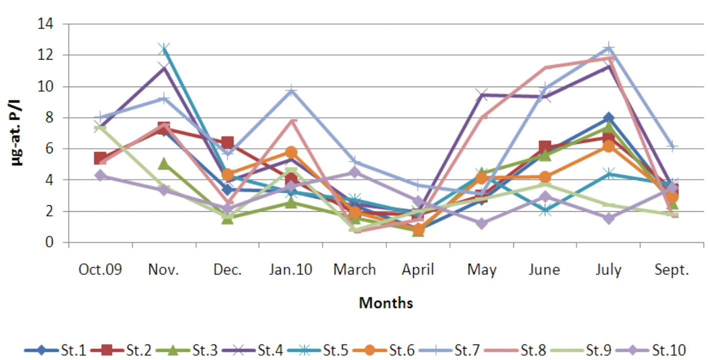

Fig. 4: Variation in phosphate-phosphorus of Shatt Al-Arab River.

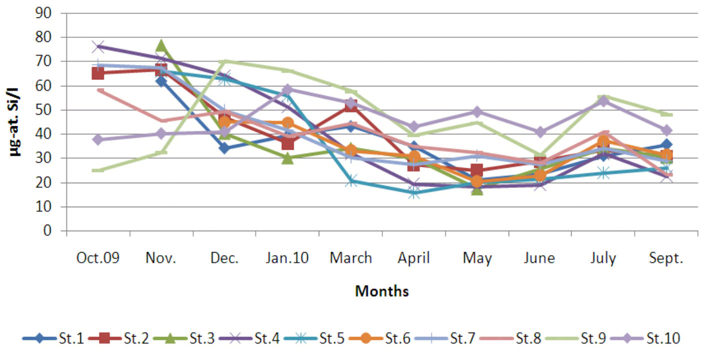

Fig. 5: Variation in silicate concentration of Shatt Al-Arab River.

Discussions:

Nutrient concentrations in rivers can vary spatially and seasonally due to natural processes and to human impacts on these ecosystems.Among all sites, the highest mean concentration of nitrite, nitrate and phosphate were recorded in water of station 7, located downstream Shatt Al-Arab River,whichis impacted by the most heavily populated area of Basrah City. Downstream river increase in nutrient is likely due to a combination of anthropogenic inputs as well as salinity- related geochemical release of phosphorus (Lampman *et al.*, 1999). Nitrification process might also be attributed for the increased concentration of nitrate downstream Shatt Al-Arab River (Bernhardt *et al.*, 2002; Hamilton *et al.*, 2001) stated that nitrification is accounted for <20% to >50% of total ammonium removal in different streams.Untreated municipal and industrial wastewater as well as fertilizers might be ascribed to high phosphate concentration (Vanni *et al.*, 2001). Dissolved forms of phosphorus are readily adsorbed into sediment particles and can be transported downstream, however, desorption of phosphate can occur when dissolved phosphate concentration is lower relative to an equilibrium phosphate value of no net exchange (House, 2003).

Between upstream stations, highest nutrient concentration was measuredat station 4. Non-point pollution source, particularly from agriculture and other diffused sources might be ascribed for this high nutrient concentration (Buhvestova *et al.*, 2011). However, interestingly low concentration of nitrite, nitrate, phosphate and silicate was measured in upstream station 6. This station is situated downstream Alhammarmarsh area which could be responsible for this reduction in concentration of nutrients because of long residence time in this water system as well as the uptake of dissolved inorganic nutrients by phytoplankton, attached algae and aquatic macrophytes.The lowest ratio of nitrate to phosphate was recorded in both station 7 and station 4. Sewage inputs into these two sites might ascribe for this low ratio, since sewage inputs tend to have relatively low N:P ratio (Downing, 1997). This would imply the relative importance of sewage impacts on these two sites.

As opposed to both nitrogen and phosphor, highest silica concentration was measured at station 10, near the mouth estuary of Shatt Al-Arab River. The predominant source of silica in aquatic ecosystem is the natural weathering of silicate materials, whereas human impact on silica concentration is through discharge of detergents and diffusion of fertilizers that contain small amounts of metasilicates (Tregyer *et al.*, 1995), whereas anthropogenic source may amount to 6% of total silica inputs into river (Sferratore *et al*. 2006).

Statistical analysis of variance indicated significant differences between stations for nitrite ($F=1.8$, $p<0.05$) and phosphate ($F=2.9$, $p<0.001$), whereas differences between stations was not significant for both nitrate and silicate. Dissolved silica displayed more seasonal variation than spatial variation (Muylaert *et al.*, 2009).

The spatial trend of nitrogen and phosphorus concentration, (Fig. 2, 3 and 4), showed a gradual decline towards the river mouth. This decline in nutrient concentration might be attributed to a reduction in both point and diffuse pollutant inputs downstream station7 and to self-purifying capacity of the river. On the contrary, silicate concentration did not decrease towards the last station in Shatt Al-Arab River. This could imply that nutrients, i.e. nitrogen and phosphorus, input into the coastal area from Shatt Al-Arab River is lower than the total load present in other downstream stations. Nevertheless, these concentrations are still high and might result in eutrophication phenomenon in the coastal area. Nutrient rich freshwater has been shown to cause eutrophication in nutrient limited coastal waters, which in certain cases results in growth of nuisance algae and in hypoxic events (Ward *et al.*, 2010). The high load of silicate into the Shatt Al-Arab River estuary would favour growth of diatoms.

Pattern of seasonal changes in nutrient concentrations is depicted in Figures 2, 3, 4 and 5. Seasonal variation in nitrite concentration was more or less pulsing. However, this variation was statistically significant ($F=7.99$, $p<0.001$). Sewage inputs of nitrogen components to rivers are often pulsed and application of fertilizers is seasonal and can alter nitrogen input to lakes and rivers (Wetzel, 2001).

Nitrate concentration showed a bimodal behavior though concentration was high during November 2009, then after decreased during March-April followed by increase towards summer 2010. Analysis of variance revealed significant seasonal changes in nitrate concentration (F=22.1, p<0.001). Nitrate concentration decrease during spring probably due to increased rate of assimilation by plankton and nitrate reduction by bacteria (Buhvestova *et al.,* 2011). High concentration of nitrate during November, 2009 and summer, 2010 could be attributed to the dry weather during 2009 that leads to decline in water discharge of Shatt Al-Arab, lower water income to the river because of dams construction in Turkey, and to the diversion of Karun River to Iranian territory. Before the diversion, Karun River discharged freshwater into Shatt Al-Arab River which might be ascribed to nutrient dilution in the main river basin.

Concentration of phosphate did not display clear seasonal trend, though temporal variation was statistically significant (F=6.7, p<0.001). Nevertheless, phosphate concentration dropped to low levels during March-April and then after gradually increased to high levels. Phosphorus delivered into rivers through point and diffuses sources. Shatt Al-Arab River is impacted by agriculture and untreated waste water disposal especially in downstream stations. The accumulation of phosphate during summer could be attributed to low river flow and less dilution of point sources (Meynendonckx *et al.*,2006). The observed decline in phosphate concentration during march-April could be due to aquatic plants and algal uptake. Both nitrate and phosphate concentrations was significantly correlated (r=0.769, p<0.01).

Temporal variation in silicate concentration was statistically significant (F=9.2, p<0.001). However, the trend of variation was irregular. Concentration of silicate in the water of Shatt Al-Arab River was low during April-May. Diatoms are the main algal group that uptake silicate and could be ascribed to the decline of silicate during spring (Wall *et al.,* 1998). These organisms are often the dominant components of river because they outcompete other algal groups due to their adaptation to turbulent water and to low light conditions (Garnier *et al.,* 1999).

Nitrite concentrations in the water of Shatt Al-Arab River varied between 1.5 and 138 µg l^{-1}. According to Wetzel (2001), nitrite concentrations are very low (< 3 µgl^{-1}) among well-oxygenated and unpolluted water. Maximum nitrate concentration in the studied area were 670 µgl^{-1}, while the maximum nitrate concentration in undisturbed tropical rivers, which is likely to represent natural value, is 190 µgl^{-1} (Lewis *et al.,* 1999). High level of nitrate was found in river water influenced by agricultural runoff (Meybeck, 1993). The concentration of phosphate varied between 21 and 390 µgl^{-1} which was higher than several UK Rivers and undisturbed rivers in Venezuela (Castillo *et al.,* 2004; Mainstone and Parr, 2002). The high levels of both dissolved inorganic nitrogen and phosphor would mean that Shatt Al-Arab water is obviously impacted by pollutants from both diffuse and point sources.

Silicate concentration did not indicate low availability in the water of Shatt Al-Arab River and never dropped below 450µg/l throughout the period of study. Martin-Jezequel*et al.,* (2000) showed that growth of diatoms is limited when silicate concentration is about 100µg/l. Although silicate concentration has been shown to affect diatom dynamics in lake water, however, silica in river is rarely in short supply (Wetzel, 2001).

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