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Nutrient Availability in River Ecosystems Follows Human Activities More than Climate Warming

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Abstract

Anthropogenic activities can greatly increase inputs of nutrients into the aquatic ecosystems resulting in shift the trophic status. To face the water crisis, understanding the role of human activities on nutrient concentrations in aquatic ecosystems needs more investigations compare to extensively studies, which have been carried out to understand these impacts on water quality of different aquatic ecosystems. We hypothesized human activates on the catchments of Tigris river may change nutrient concentrations in water along the river. The results showed that phosphate concentration differed significantly among the studied sites due to distributed human activities, while nitrate concentration did not. Phosphate and nitrate concentrations were not affected by water temperature. We concluded that human activities on the surrounding landscapes could be more essential sources for nutrients of aquatic ecosystems than role of ongoing climate warming. Despite the role of warming in driving nutrients availability in aquatic ecosystems, our findings suggest to take the different activates on the surrounding catchments into account in the studies caring about trophic status classification of aquatic ecosystems.

Keywords: Anthropogenic; Phosphate; Nitrate; Warming

Introduction

Nutrients are the most important elements and compounds that living organisms such as plants, algae, and microbes need for growth and reproduction processes. In aquatic ecosystems, nitrogen, phosphorous, and silica are the essential nutrients and their impacts are seen in many situations; including their role as limiting factors of producer's biomass growth and primary production as well as their effects on aquatic communities composition [1-6]. Then causing variations in trophic levels of food webs [7-9]. In aquatic ecosystems, nutrients are produced either naturally through weathering processes and as products by producers [10] or artificially through sewage discharges, atmospheric releases from the burning of fossil fuels, and by runoff from the surrounding areas that have been fertilized with agricultural pesticides [11,12]. Nutrients are affected by different factors, temperature is the most climate factor controlling soil nitrogen and phosphorous, whereas warming promotes the breakdown of soil organic matters as well as accumulates the accessible phosphorus and nitrogen [13].

The Tigris River, one of the main rivers in Iraq and a vital source of water, its water is utilized for recreational, industrial, agricultural, municipal, industrial, and household uses. Most of the studies on the Tigris River focused at how do nutrients affect the quantity and quality of diatoms as well as zooplankton in the Tigris River [14,15]. As well, it is believed that Tigris eventually receives all wastewater produced by the aforementioned operations [16]. Tigris had been monitored for a long time, and several researches had been done on it. Some studies focused on variations of chemical physical properties and nutrients concentrations for water of Tigris River, monthly [17] or seasonally [18,19]. Nutrients are used as a water quality indicator for Tigris River [20-24]. While, still there is a lack in understanding the changes in nutrients concentrations in rivers and more investigations are needed for that. We hypothesized that human activities can play an important role in driving nutrients availability in rivers ecosystems taking Tigris River as an example to study.

Materials and Methods

Study Site Description

This study was carried out at some locations in the Tigris River in Baghdad (Figure 1). The Tigris River enters Baghdad city at a place around 5 km from the tourist island in Baghdad. The river, which flows from the north to the south, divides the city into two sections: the right (Karkh) and the left (Risafa). It has a slope of 6.9 cm per kilometer and a width that ranges from 160 meters in straight area to more than 400 meters in twisted areas.

The Tigris River is affected by a number of variables, some of which are influenced by climate change, such as temperature variance and rain frequency. Other factors brought on human activities including irrigation, drainage projects and dams like the Samarra Dam, which regulate water flow and level and raise saline content when water returns from the dams to rivers.

For carrying out our study three sites were selected on the Tigris River to collect the water samples. The estimated distance of the Tigris River between the sites is more than 10-km, where it is about 20-km from the first station to the third station, which are: AL-Gherai'at, this area is a permanent island located in the northeast of Baghdad on the side of Rusafa, and characterized by being covered with wild plants. Tigris River in this region occurs under influence of direct sewage discharge coming from Al-Gherai'at's inhabited residential areas. The second area is AL-Shuhda'a Bridge that is one of the main bridges in Baghdad, linking the two sides of Karkh and Rusafa; it is regarded as an active site due to overpopulation and restaurants, which discharge liquid pollutants into the river.

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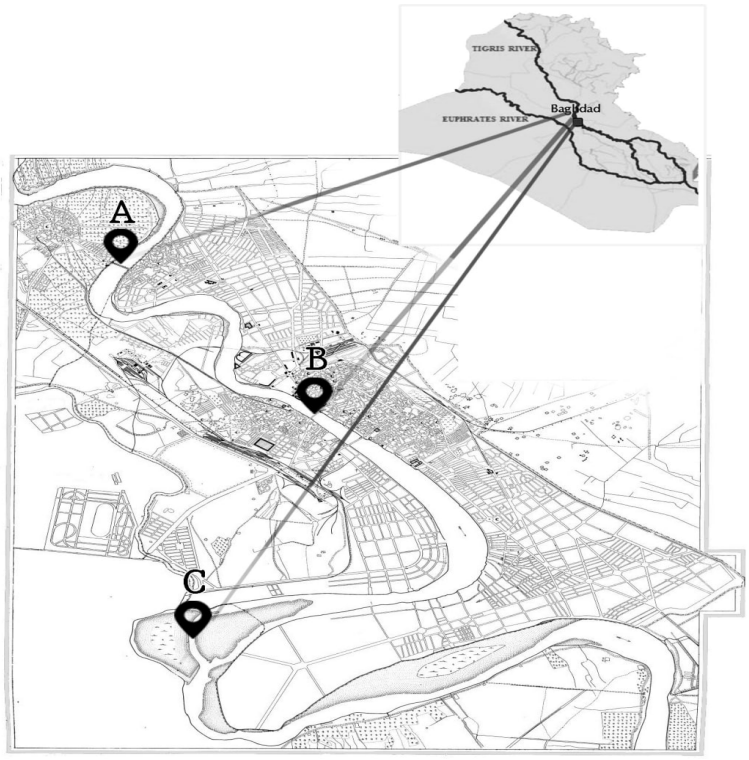

Figure 1: Map of the studied sites (A-C) on Tigris River in Baghdad. A) AL-Gherai'at, B) AL-Shuhda'a Bridge, and C) AL-Jadriyah.

The third area is AL-Jadriyah that is an area on the side of Rusafa, where the Tigris River takes a considerable turn and travels northeast. AL- Jadriyah region is one of the regions that in comparison to the sites previously described as a fast urbanization and residential expansion, resulting in a considerable amount and variety of liquid wastes.

Measuring Nutrient and Temperature

All parameters were measured by using the standard methods in (APHA, 2005). Water temperature (°C) was measured by AL-Hana portable pocket thermometer. For nitrate (NO_3) 50 ml of water sample is taken. 1ml of HCl (1N) was added for each sample, and then measured by using a spectrophotometer for two wavelengths (220 nm). For reactive phosphate (PO_4), the ascorbic acid method described in was used. This method involves adding 8ml of a compound solution made up of ascorbic acid, sulfuric acid, antimony potassium tartrate, and ammonium molybdate to 50 ml of the filtered sample and diluting it to 50 ml with distilled water, a blue complex solution is formed. Then measured the optical absorption of the complex solution at 860nm wavelength [25].

Statistics Analyses

For statistical analyses (in SPSS 20) all variables were analyzed. T-tests estimated the differences variables between specific locations. One-way ANOVAs test was used to show if the variables were significantly different between the different locations. Person´s correlation coefficient (r) was used to show the correlation between water temperature and nutrients concentrations. Linear regression was used to show if the correlations were significant or not. As well, we found the mean and the standard divisions for all measured parameters.

Results

Average (±1 SD) of water temperature among the studied sites ranged between (15.5±0.1) and (15.9±0.02). Water temperature did not differ between the stud (one-way ANOVA: F2, 17 = 0.014, p = 0.98). Water temperature did not show effects on nutrient concentrations during the study (r = 0.58, p = 0.10 and r = 0.37, p = 0.32) for PO_4 and NO_3, respectively (Figure 2a, b).

PO_4 concentration differed among the studied sites (one-way ANOVA: F2, 17 = 5.59, p = 0.01). Average (±1 SD) of phosphate concentration was ranged from the lowest value (0.08±0.01 µg/l) in Al-Gherai´at site to the highest value (0.15±0.02 µg/l) in AL-Jadriyah site (Figure 3a). There were significant differences in phosphate concentration between some specific sites (t-test: df = 5, t = -1.77, p = 0.04 and df = 5, t = -5.21, p = 0.001), respectively between Al-Gherai´at and Al-Shuhda´a Bridge; Al-Gherai´at and AL-Jadriyah, while it did not show significant difference between Al-Shuhda´a Bridge and AL-Jadriyah (t-test: df = 5, t = -1.11, p = 0.15) (Figure 3a).

NO_3 concentration did show significant differences among the studied sites (one-way ANOVA: F2, 17 = 0.89, p = 0.42). Average (±1 SD) of NO_3 concentration was ranged from the lowest value (0.87±0.27 µg/l) in Al-Shuhda´a Bridge site to the highest value (1.40±0.77µg/l) in AL-Jadriyah site (Figure 3b).

Discussion

Phosphate concentration demonstrated significant differences among the studied sites, while nitrate concentration did not differ significantly. The changes in phosphate concentration were not attributed to impacts of water temperature. These findings suggest that phosphate concentration can be influenced by different human activities on the surrounding catchments of aquatic ecosystems more than nitrate.

Some studies have revealed that water temperature has significant effects on nutrients due to that warming enhance releasing nutrients

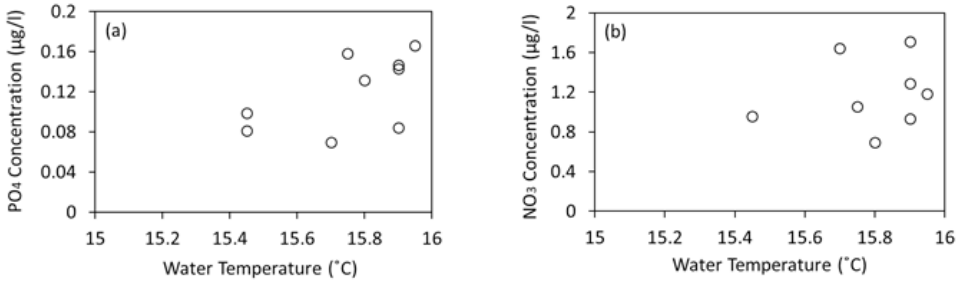

Figure 2: Relationships between water temperature and phosphate concentration (a) and nitrate concentration.

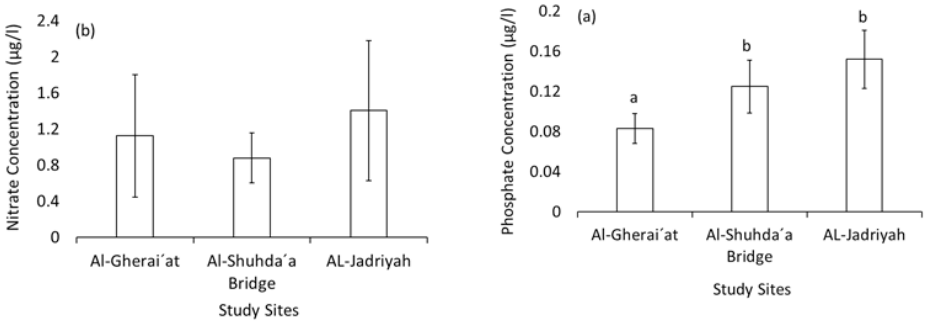

Figure 3: Nutrient concentrations of the different studied sites, a) Phosphate concentration and b) Nitrate concentration. The different letters on the error bars mean significant differences at the significant level (p-value <0.05).

from sediments [26]. The positive relationship between increasing water temperature and released nutrient is accompanied by an increase in the mineralization processes that carried out by microorganisms [27]. While, our results did not show significant correlations between water temperature and nutrient concentrations that supports our hypothesis that human activities are main drivers of nutrient concentrations in some aquatic ecosystems, especially closed to urbanization areas.

The main inorganic phosphorus component in water is active phosphate [28]. Phosphate levels in natural water are often low, as it has been noticed [29]. Low phosphate concentrations would be expected because it could be absorbed by soil particles and be hard to re-melt [30]. Phosphate is an essential element of all biological aquatic systems and processes, which can be affected by abundance of aquatic species, composition of soil and rocks, and other variables [31]. The differences in phosphate concentration along the studied sites could be attributed to phosphate inputs via industrial waste and sewage, detergents [32]. Further, the changes in phosphate concentration along the river due to run-off of fertilizers that used in agriculture [33-35]. On another hand, the differences in phosphate concentration among the studied sites can be attributed to different people population density and increased urbanization on the riversides e.g. presence of restaurants can lead to a rise in the dumping of residue directly into the river like food waste and detergents like soap. It has been revealed that urbanization on the ground along riverbanks where detergent especially dishwashing detergent is could be a main source of phosphate into aquatic ecosystems [36].

On another hand, nitrate in aquatic ecosystems is the main form of inorganic nitrogen [30-43] and it is a product of the biological breakdown of organic nitrogen molecules, whether they are in their native or contaminated forms. Many studies showed that human activities like using fertilizers in agriculture have an effect on nitrate concentrations in the aquatic ecosystems [44-45]. While our results did not show significant differences in nitrate concentration among the studied sites along Tigris River that may be due to receiving same amounts of nitrate from the urbanization areas at the different places via the presence of restaurants or people residential areas.

On another hand, it is uncommon to find a reclaimed land for agriculture around the studied sites while nitrate is an important element of chemical nutrients that are used in agriculture. For agriculture, the farmers always use ammonia (NH_4) as chemical nutrients that will be transformed by bacteria to nitrate, while phosphorous important component of domestic detergents [46]. These could be reasons for increasing phosphate, but not nitrate.

Conclusions

Overall, our results revealed that warming does not influence nutrient concentration clearly, whereas phosphate concentration could be impacted by urbanization areas around the aquatic ecosystems more than nitrate. We can conclude that anthropogenic activities can control nutrients concentration in aquatic ecosystems more than climate warming. We suggest to take the different human activates on the surrounding aquatic ecosystem catchments into account in the studies care about aquatic trophic status classification.

Author Contributions

The two authors designed the study; B.K. carried out the field and lab work; The data were analyzed statistically by M.H.; The first draft of the manuscript was written by B.K.; The final version of the manuscript was revised by M.H.

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Data Availability Statement

The data that support the findings of this study are available by the corresponding author upon request.

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Conflict of Interest

The authors declare no conflict of interest.

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