Journal of the Persian Gulf
(Marine Science)/Vol. 8/No. 29/ September 2017/10/37-46

Assessment of physical, chemical and biological parameters in the Nayband Mangrove Ecosystem (Bushehr Province, Iran)

Maryam Ghaemi[1*], Sara Gholamipoor[2]

1- Department of Marine Living Science, Iranian National Institute for Oceanography and Atmospheric Sciences (INIOAS), Bushehr, Iran
2- Laboratory expert, Iranian National Institute for Oceanography and Atmospheric Sciences, Persian Gulf Oceanography Center (Bushehr), email: saragholamipoor@gmail.com

Received: April 2017 *Accepted: September 2017*

Abstract

In this study, the changes in nutrient concentration, chlorophyll *a*, total alkalinity and physicochemical parameters of surface water at mangrove and marine stations in Nayband mangrove ecosystem were investigated. Water samples were collected from 4 stations distributed throughout the mangrove forest and 3 stations in the coastal water of the Persian Gulf during two seasons of summer and winter. The results showed that the average of salinity and temperature at mangrove stations in the summer was significantly higher than the winter and the mean pH and dissolved oxygen in the winter was significantly higher than the summer ($p<0.05$). Statistical comparison showed that mean concentration of phosphate, silicate, chlorophyll *a* and total alkalinity in surface waters of mangrove forests in the summer was significantly higher than the winter ($p<0.05$), and mean concentration of nitrite, nitrate and ammonium in the winter was significantly higher than the summer at mangrove stations. In addition, the statistical comparison showed that the mean concentration of nutrients (phosphate, silicate, nitrite and ammonium) and chlorophyll *a* at mangrove stations was significantly higher than marine stations ($p<0.05$) in both seasons.

Keywords: Mangrove, Nayband, Nutrient, Chlorophyll *a*, Total alkalinity.

1. Introduction

Productive wetlands, which support biodiversity and ecosystems, are essential parts of the environment. The wetlands also regulate water quality, quantity, nutrient cycling and act as a buffer between terrestrial and aquatic systems [1]. Mangrove ecosystems are productive wetlands found in tropical and subtropical regions which provide suitable shelter for both marine and terrestrial organisms [2]. Human interferences with the landscape have widespread influences on wetlands [3] and global warming [4]. Consequently, water temperature [5] and in-stream biogeochemical processes are altered [6]. The healthy aquatic ecosystem depends on the physico-chemical and biological characteristics [7]. Therefore, several studies have been conducted to evaluate the health status of mangroves ecosystems by measuring physicochemical parameters [8-12].

* *Email: mghaemi@inio.ac.ir*

The Nayband, the largest mangrove forest located in the Bushehr province, is largely affected by oil and gas activities and their pollution, land reclamation, agricultural and aquaculture activity, over using natural resources, and changing land-use. Road construction has been led to hydrological changes and subsequent decline of mangrove forests of east Nayband Bay. The present investigation is an attempt to study some of the crucial, physical, chemical and biological parameters of Nayband mangrove ecosystem in relation to the assessment of the state of health of the mangroves. To our best knowledge, studies of parameters, such as chlorophyll *a*, nutrient concentrations (nitrate, nitrite, ammonium, phosphate, and silicate) and total alkalinity at this valuable ecosystem has not been reported so far.

2. Material and Methods

2.1. Study Area

The Mangrove forests of Nayband, are the widest mangrove communities in above 27 degrees' latitude in the northern coast of the Persian Gulf, and the last dense and extensive complex of these ecosystems in the northwest Indian Ocean and has an area of about 390 hectares. Water samples were collected from four stations distributed throughout the mangrove forest and three stations in the coastal water of the Persian Gulf as a reference (Figure 1). Sampling was carried out during summer (September, 2016) and winter (February, 2017) seasons. From each station three replicate samples were taken. According to meteorological data obtained from the Bushehr Metrological Agency the air temperature showed marked variation in relation to seasons. The mean atmospheric temperature varied from 24.1 to 38.5 °C during the winter and summer, respectively.

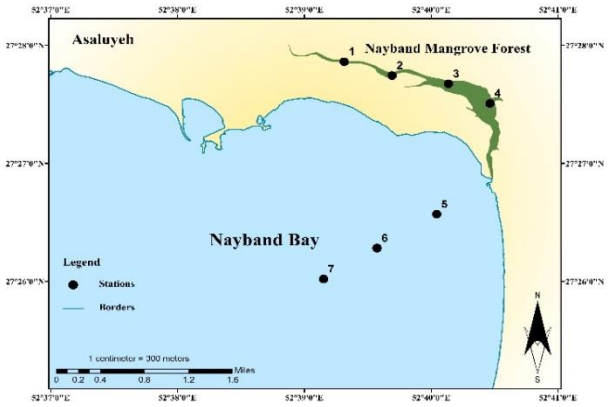

Fig 2: Sampling stations

2.2. Analytical Method

Concentration of nutrients and chlorophyll *a* were measured by colorimetric [13] and spectrophotometric method, respectively [14]. Total alkalinity was measured by open-cell potentiometric titration [15]. Dissolved oxygen (DO) and pH was measured using Hack multi meter (HQ40d). Salinity was measured using a WTW 3210 portable meter.

2.3. Statistical Analysis

For Statistical analysis, the SPSS software version 22 was used. To obtain the distribution of data the Klomogrov-Smirnov test was used. The statistical differences were determined by Mann-Whitney U test. Spearman test was used to determine the correlation between the parameters.

3. Results and discussion

3.1. Physicochemical parameters

Figure 2 shows the measured physicochemical parameters of surface water on the coastal water of the Persian Gulf (marine stations) and near the mangrove trees (mangrove stations). Most studied physicochemical parameters showed significant differences between stations and seasons.

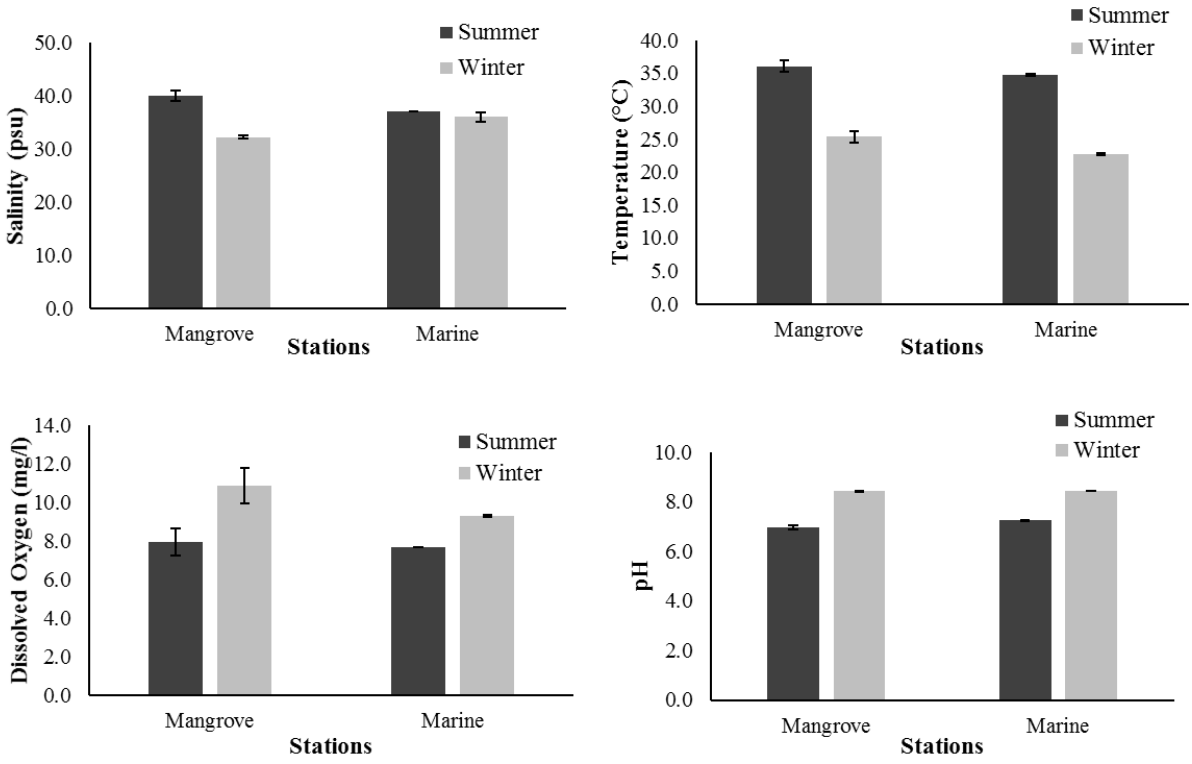

Fig 2: Mean values of studied physicochemical parameters at mangrove and marine stations in the winter and summer seasons.

Aaverage water temperature ranged from 36.05±0.84 °C to 34.73±0.14 °C and between 25.35±0.82 °C and 22.73±0.13 °Cat mangrove and marine stations. Temperature is the most important factor to maintain the growth, reproduction, survival, and distribution of organisms in the environment [16]. The mean water temperatures in the summer were higher than the winter at all studied stations.

Figure 2 shows the average salinity in the summer was higher than in the winter. The average salinity ranged from 40.0±0.9 to 37.1±0.06 psu and between 32.2±0.2 and 36.1±0.9 psu in the summer and winter at mangrove and marine stations, respectively. Generally, changes in the salinity in the brackish water habitats, such as estuary, backwater, mangroves and coastal waters are because of the influx of freshwater from river, by land runoff caused by monsoon or by tidal variations. This could be attributed to high degree of evaporation with decreased freshwater inflow and land drainage [17]. Metrological data obtained from the Bushehr Metrological Agency was shown that the total amount of rainfall was about 327 mm during the winter and no rainfall during the summer. The highest rainfall was recorded in February, 2017 (287 mm). These values were expected to result in a marked decrease in salinity at the mangrove stations.

pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body. In unpolluted waters, pH is principally controlled by the balance between the carbon dioxide, carbonate and bicarbonate ions as well as other natural compounds such as humic and fulvic acids. The natural acid-base balance of a water body can be affected by industrial effluents and atmospheric deposition of acid-forming substances [18]. Diel variations in pH can be caused

by the photosynthesis and respiration cycles of algae in eutrophic waters [19]. A combination of several factors would influence the pH of the mangrove lagoon water system. The pH of seawater is usually relatively stable for tropical systems ranging between7.4-8.5. Any significant deviations above or below this normal range suggests some form of disturbance [18]. The average pH values in the winter were 8.4 at mangrove and marine stations (Figure 2). But, the average pH values in the summer varied from 6.9 to 7.2 at mangrove and marine stations, respectively. This decrease may be because of presence of oil and gas facilities nearby the Nayband ecosystem and thus, it affected by oil and gas activities and their pollution (increasing CO2 levels of the atmosphere and other greenhouse gases). The hydrolysis of CO2 in seawater increases the hydrogen ion (H+) concentration and thereby reduces the pH of seawater, a term coined "ocean acidification" [20]. As oceans become less basic, the ability of marine calcifies to form calcite and aragonite skeletons decreases [21]. Moreover, when pH of water decreases below 7, it dissolves many metals resulting in their toxicity [22]. Also, higher pH values recorded in the winter were accompanied by a relative increase in the concentration of DO (pH shows a positive correlation with DO).

Average dissolved oxygen for the sample period ranged between 7.94±0.7 to 7.68±0.02 mg/l and 10.87±0.9 mg/l to 9.31±0.04 in the summer and winter at mangrove and marine stations, respectively.. The DO content of natural waters varies with temperature, salinity, turbulence, the photosynthetic activity of algae and plants, and atmospheric pressure. The solubility of oxygen decreases as temperature and salinity increase. Significant variations in DO can occur seasonally or even over 24 hour periods, in relation to temperature and biological activity (i.e. photosynthesis and respiration). Increases in DO relate to phytoplankton concentrations as algal blooms in eutrophic waters can cause DO concentrations to rise dramatically [19]. The statistical analysis shows that the mean DO in the winter is significantly higher than the summer ($p<0.05$) at all stations and this might be because of the cumulative effect of lower water temperature with heavy rainfall and the resultant fresh water mixing [12, 23]. The present study also showed an oxygen super-saturation (>5.66 mg/l) in the Nayband ecosystem, it might be because of higher rate of photosynthesis and limited flushing [24].

3.2. Nutrient analysis

In mangrove ecosystem, nutrients are considered as the most important parameters that influence growth, reproduction and metabolic activities of biotic components. The distribution of nutrients is mainly based on season, tidal conditions and fresh water influx from land [25]. As shown in Figure 3, the average nitrite, nitrate and ammonium concentrations in the winter was significantly ($p<0.05$) higher than the summer, at mangrove stations. This might be because of heavy rainfall in the winter (total rainfall in February was 287 mm). Similar finding has been reported by other researcher [26, 27]. Anbazhagan suggested that the addition of nitrogenous nutrients mainly through freshwater and terrestrial runoff in the lagoon definitely increased the level of nitrogenous nutrients [28]. Moreover, lower values in the summer compared to the winter might be because of utilization of these nutrients by benthic algae and phytoplankton, which is abundant in the summer [10] (these nutrient concentrations showed a negative correlation with Chlorophyll *a* ($p<0.05$)). Also, average concentration of phosphate and silicate in the surface waters of sampling stations, in the summer was significantly higher than the winter ($p<0.05$). This might be because of the release of silicate and phosphate from the bottom sediment and exchange with overlying water [29]. According to Saisastry and Chandramohan, the

mudflat and mangroves are known to trap phosphates during period of annual run off and release the same at a later time to the water [30]. Similar finding has been reported by Ghaemi in the Mond estuary ecosystem (Bushehr province) [31]. In addition, the statistical comparison showed that the mean concentration of nutrients at mangrove stations was significantly higher than marine stations ($p<0.05$) in both seasons.

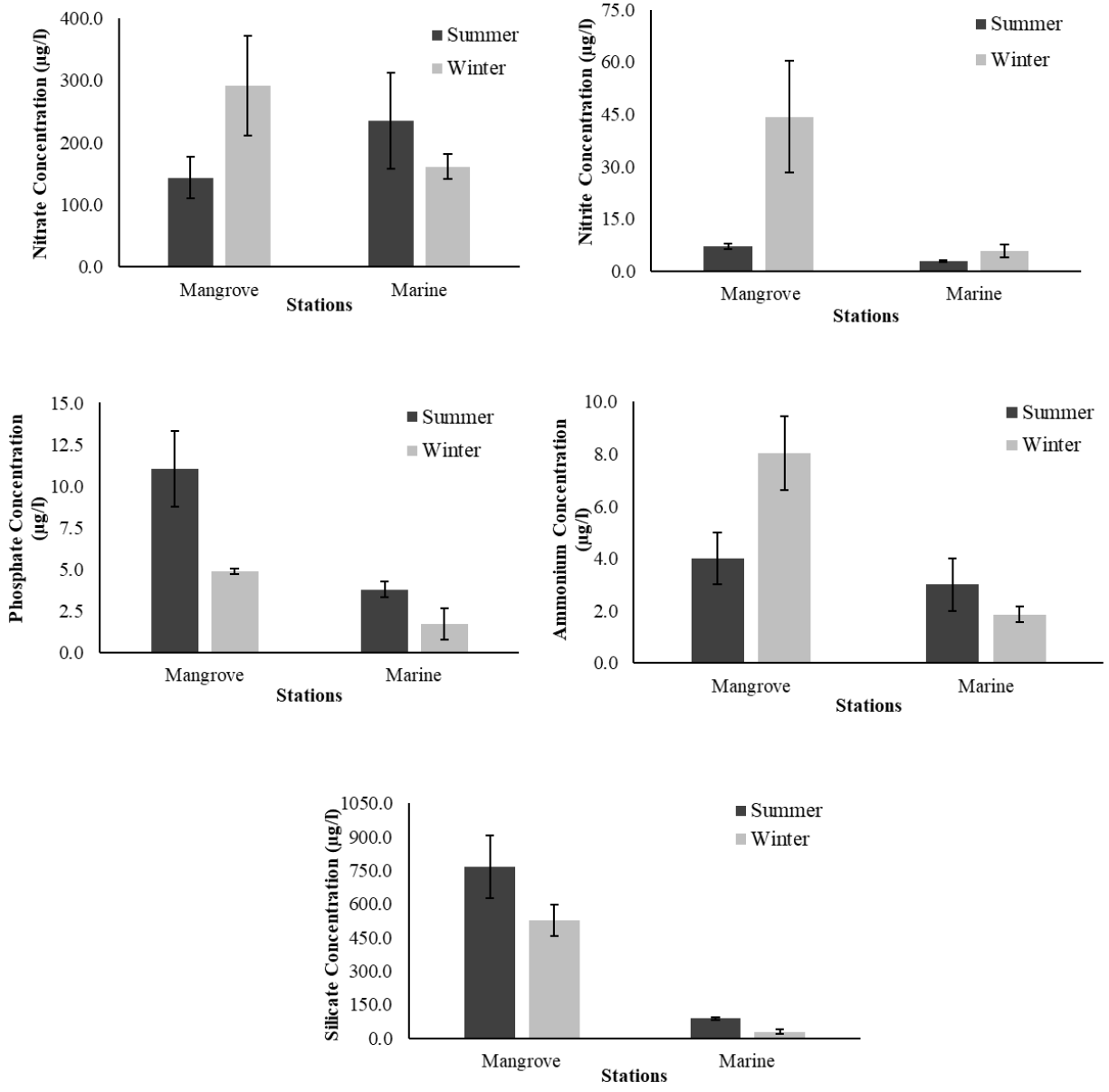

Fig 3: The mean (± SE) concentration of nutrients, at mangrove and marine sampling stations in the winter and summer seasons

3.3. Chlorophyll *a* analysis

The lowest (i.e. 21.6°C) and highest (i.e. 32.9°C)

Chlorophyll *a*, a characteristic algal pigment, constitutes approximately 1% to 2% (dry weight) of planktonic algal biomass. This feature makes chlorophyll *a*, a convenient indicator of algal biomass. High concentrations of chlorophyll *a* would result in high values of productivity and high phytoplankton biomass [25]. Rossouw reported that chlorophyll *a* concentration can be considered the most important biological response variable for nutrient related problems [32]. Phytoplankton biomass (Chlorophyll *a*) was among the most reliable planktonic indices distinguishing four groups with different water qualities: oligotrophic (0.21-0.55 µg/l), mesotrophic (0.57–2.55 µg/l), eutrophic (3.00 to 6.55 µg/l) and extremely eutrophic (>31.17 µg/l) [18]. According to Figure 4, mean chlorophyll *a* concentration in the summer were significantly ($p < 0.05$) higher than the winter. Also, the mean chlorophyll *a* content in the both seasons at mangroves stations were significantly higher than those of marine stations ($p < 0.05$). In the present research, the mean chlorophyll *a* concentration in the surface water corresponded to published values for mesotrophic surface tropical waters (1.03-1.82 µg/l at marine statins; 1.38-2.03 µg/l at mangrove stations). In general, the average chlorophyll *a* concentration in different regions of the Persian Gulf has been reported differently, for example, in surface waters of Kuwait 2.23 µg/l, Qatar surface waters 2 to 4 µg/l, and in the total surface waters of Persian Gulf, 0.3-0.8 µg/l [33].

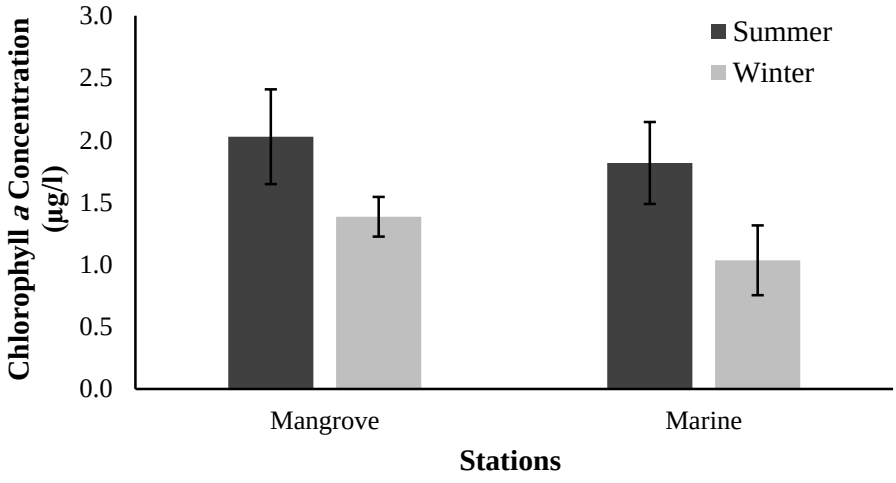

Fig 4: The mean (± SE) concentration of chlorophyll *a*, at mangrove and marine sampling stations in the winter and summer seasons

3.4. Total alkalinity analysis

Alkalinity of a water body is a measure of its capacity to neutralize acids to a designated pH [34, 35]. Alkalinity is an indirect measure of the concentration of anions in water. The dissolved anions according to McNeely et al. [36] may be sourced from bicarbonates, carbonates, hydroxides, phosphates borates or silicates which may be derived from industrial wastes, dissolved rocks, salts, soils or bottom sediments. Figure 5 shows the measured total alkalinity of surface water in two seasons at mangrove and marine stations. The results showed that the average of alkalinity in the summer was

significantly higher than the winter ($p<0.05$). The increase in alkalinity during the summer seasons may be because of industrial discharges, as well as low rainfall, high evaporation, sea water intrusion [9]. The results of this study showed that there is a linear relationship between alkalinity and salinity in the summer, while there is no linear relationship between alkalinity and salinity in the winter season. This may be because of the mixing of fresh water resources, such as rainfall, in the winter [37].

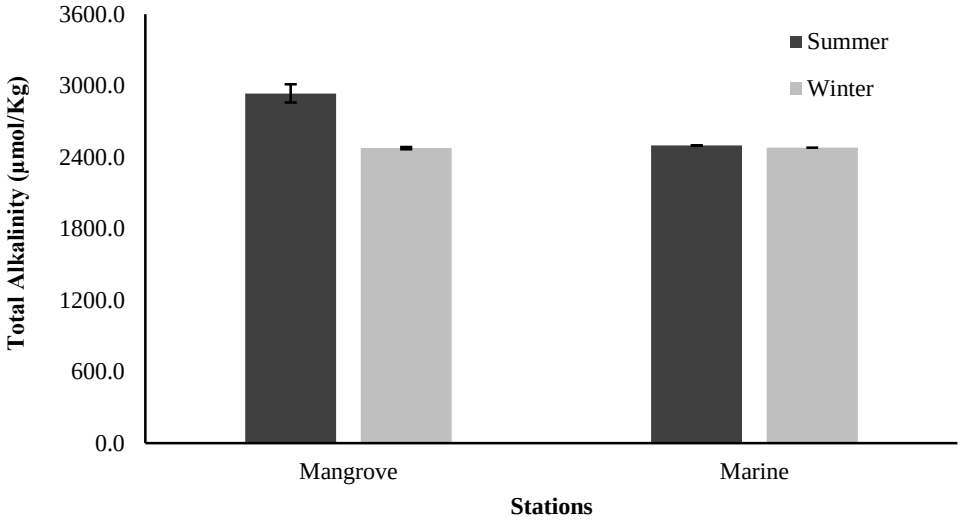

Fig 5: The mean (± SE) total alkalinity, at mangrove and marine sampling stations in the winter and summer seasons

4. Conclusions

The present study was carried out to assess physical, chemical and biological parameters of the Nayband mangrove ecosystem. The study revealed that the parameters like water temperature, pH, salinity, dissolved oxygen, total alkalinity, chlorophyll *a*, nitrite, nitrate, ammonium, phosphate, and silicate exhibited considerable seasonal and spatial variations.

Based on this study, it became clear that the vicinity of oil and gas facilities to the Nayband forest and their pollutions has affected the quality of the water, as manifested by the high level of DO and decrease of surface water pH below the Persian Gulf surface water pH (8.1-8.2). The decrease of surface water pH might be because of greenhouse gases emission from oil and gas facilities. It is, therefore, highly recommended to decrease or stop of CO2 emission and sewage discharge inside this valuable ecosystem. Results obtained during this study will serve as a baseline data for further follow-up study in the environment of this economically important mangrove ecosystem in the Persian Gulf.

Acknowledgements

Authors would like to thank Iranian National Institute for Oceanography and Atmospheric Science (INIOAS) for funding of this project (project no. 395-011-01-016-06) in terms of sampling, field measurements and laboratory analysis.

References

Islam, S.N. and Gnauck, A., 2009. Threats to the Sundarbans mangrove wetland ecosystems from transboundary water allocation in the Ganges basin: A preliminary problem analysis. International Journal of Ecological Economics & Statistics, 13(W09), pp.64-78.

Gopal, B. and Chauhan, M., 2006. Biodiversity and its conservation in the Sundarban mangrove ecosystem. Aquatic Sciences, 68(3), pp.338-354. https://doi.org/10.1007/s00027-006-0868-8

Chang, H., 2007. Comparative streamflow characteristics in urbanizing basins in the Portland Metropolitan Area, Oregon, USA. Hydrological Processes: An International Journal, 21(2), pp.211-222. https://doi.org/10.1002/hyp.6233

Oke, T.R., 1987. Boundary Layer Climates, Methuen, New York.

Nelson, K.C. and Palmer, M.A., 2007. Stream temperature surges under urbanization and climate change: data, models, and responses 1. JAWRA Journal of the American Water Resources Association, 43(2), pp.440-452. https://doi.org/10.1111/j.1752-1688.2007.00034.x

Baker, A., 2005. Land use and water quality, Encyclopedia of Hydrological Sciences. https://doi.org/10.1002/0470848944.hsa195

Venkatesharaju, K., Ravikumar, P., Somashekar, R.K. and Prakash, K.L., 2010. Physico-chemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. Kathmandu University Journal of Science, Engineering and Technology, 6(1), pp.50-59. https://doi.org/10.3126/kuset.v6i1.3310

Srilatha, G., Thilagavathi, B. and Varadharajan, D., 2012. Studies on the physico-chemical status of Muthupettai mangrove, south east coast of India. Advances in Applied Science Research, 3(1), pp.201-207.

Rahman, M.M., Rahman, M.T., Rahaman, M.S., Rahman, F., Ahmad, J.U., Shakera, B. and Halim, M.A., 2013. Water quality of the world's largest mangrove forest. Can Chem Trans, 1(2), pp.141-156. https://doi.org/10.13179/canchemtrans.2013.01.02.0018

Srilatha, G., Varadharajan, D., Chamundeeswari, K. and Mayavu, P., 2013. Study on physico-chemical parameters in different mangrove regions, Southeast Coast of India. J Environ Anal Toxicology, 3(182), pp.2161-0525.

Rahaman, S.M.B., Sarder, L., Rahaman, M.S., Ghosh, A.K., Biswas, S.K., Siraj, S.S., Huq, K.A., Hasanuzzaman, A.F.M. and Islam, S.S., 2013. Nutrient dynamics in the Sundarbans mangrove estuarine system of Bangladesh under different weather and tidal cycles. Ecological Processes, 2(1), p.29. https://doi.org/10.1186/2192-1709-2-29

Arumugam, A. and Sugirtha, P.K., 2014. Evaluation of physicochemical parameters and nutrients in the Mangrove ecosystem of Manakudy Estuary, Southwest coast of India. International Journal of Latest Research in Science and Technology, 3(6), pp.205-209.

MOOPAM., 1999. Manual of Oceanographic Observation and Pollutant Analysis Methods, ROPME Publishing.

ESS Method 150.1: Chlorophyll - Spectrophotometric, 1991. Environmental Sciences Section Inorganic Chemistry Unit, September, Volume 3, Chapter 4.

Dickson, A.G., Sabine, C.L. and Christian, J.R., 2007. Guide to best practices for ocean CO2

measurements. North Pacific Marine Science Organization.

Langford, T., 1990. Ecological effects of thermal discharges. Springer Science & Business Media.

Srilatha, G., Thilagavathi, B. and Varadharajan, D., 2012. Studies on the physico-chemical status of Muthupettai mangrove, south east coast of India. Advances in Applied Science Research, 3(1), pp.201-207.

Campbell, P.E., Janette A, M., Webber, M.K. and Webber, D.F., 2008. Planktonic communities as indicators of water quality in mangrove lagoons; a Jamaican case study. Transitional Waters Bulletin, 2(3), pp.39-63.

Chapman, D., and Kimstach, V., 1996. Selection of water quality variables in Chapman, Water quality assessments: A guide to the use of biota, sediments and water in environmental monitoring (2nd ed.), pp:59-126.

Caldeira, K. and Wickett, M.E., 2003. Oceanography: anthropogenic carbon and ocean pH. Nature, 425(6956), p.365. https://doi.org/10.1038/425365a

Kleypas, J.A., Buddemeier, R.W., Archer, D., Gattuso, J.P., Langdon, C. and Opdyke, B.N., 1999. Geochemical consequences of increased atmospheric carbon dioxide on coral reefs. science, 284(5411), pp.118-120. https://doi.org/10.1126/science.284.5411.118

Behera, B.C., Mishra, R.R., Patra, J.K., Dutta, S.K. and Thatoi, H.N., 2014. Physico-chemical properties of water sample collected from mangrove ecosystem of Mahanadi River Delta, Odisha, India. American journal of marine science, 2(1), pp.19-24.

Fatema, K., Maznah, W.W. and Isa, M.M., 2015. Spatial variation of water quality parameters in a mangrove estuary. International Journal of Environmental Science and Technology, 12(6), pp.2091-2102. https://doi.org/10.1007/s13762-014-0603-2

Manju, M.N., Resmi, P., Gireesh Kumar, T.R., Kumar, R., Rahul, R., Joseph, M.M. and Chandramohanakumar, N., 2012. Assessment of water quality parameters in mangrove ecosystems along Kerala coast: a statistical approach. International journal of environmental research, 6(4), pp.893-902.

Saravanakumar A., Rajkumar M., SeshSerebiahs J., Trivakaran G.A., 2008. Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in avid zone mangroves of Kachchh-Gujarat. Journal of Environmental Biology, 29 (5), pp.725-732.

Srilatha, G., Varadharajan, D., Chamundeeswari, K. and Mayavu, P., 2013. Study on physico-chemical parameters in different mangrove regions, Southeast Coast of India. J Environ Anal Toxicol, 3(182), pp.2161-0525. https://doi.org/10.4172/2161-0525.1000182

Arumugam, A. and Sugirtha, P.K., 2014. Evaluation of physico chemical parameters and nutrients in the Mangrove ecosystem of Manakudy Estuary, Southwest coast of India. International Journal of Latest Research in Science and Technology, 3(6), pp.205-209.

Anbazhagan, P., 1988. Hydrobiology and benthic ecology of Kodiakkarai coastal sanctuary (Southeast coast of India). Annamalai University, India.

Chester, R., 1990. Marine geochemistry (Academic Press Inc. London), pp.272. https://doi.org/10.1007/978-94-010-9488-7_9

Saisastry, A.G.R. and Chandramohan, P., 1990. Physicochemical characteristics of Vasishta Godavari estuary, east coast of India: Pre-pollution

status.

Ghaemi, M. and Gholamipoor, S., 2017. Study of temporal and spatial variation of nutrients and total alkalinity in the Mond estuary ecosystem, Oceanography, 8(30), pp.11-18 (In Persian with English summary). https://doi.org/10.29252/joc.8.30.11

Rossouw N. Chlorophyll *a* as indicator of algal abundance. 2003. Algal_Abundance_V01.htm. http://www.ru.ac.za/static/institutes/iwr/software/reserve/wqdss/

Al-Majed N, Mohammadi H, Al- Ghdban A., 2000. Regional report of the state in the marine environment. (ROPME), 187P.

American Public Health Association (APHA), 1980. Water Pollution Method for the Examination of Water and Wastewater. 18 ed., Washington D.C., pp: 1437.

Edokpayi, C.A., 2005. Variation of chemical constituents of a brackish water prawn habitat in southern Nigeria. Acta Satech, 2(1), pp.11-18.

McNeely, R.N., V.P., Neimanis and Dweyer, L., 1979. Water Quality Source Book: A Guide to Water Quality Parameters. Inland Waters Directorate, Water Quality Branch Ottawa, Canada, pp: 88.

Cai, W.J., Hu, X., Huang, W.J., Jiang, L.Q., Wang, Y., Peng, T.H. and Zhang, X., 2010. Alkalinity distribution in the western North Atlantic Ocean margins. Journal of Geophysical Research: Oceans, 115(C8). https://doi.org/10.1029/2009JC005482