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Relationship between physicochemical and habitat parameters with abundance of benthic macroinvertebrates in assessment of water quality

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ABSTRACT

Benthic macroinvertebrates are commonly used for assessment of water quality. Usually, these insects in rivers are present, easily collected, not moving much and it is easy to detect kinship. Benthic macroinvertebrates can also show changes in water quality and as sensitive indicators of environmental change are used. Jajrud River originated from the Elburz Mountains in northern Tehran. A sampling of Jajrud River benthic macroinvertebrate organisms from a Surber sampler device with an area of 900 cm^2 and mesh size of 250-micron was repeated three times at each station. Physicochemical parameters including Elevation, Depth, Flow Velocity (WatFlow), Water Temperature (WatTem), Turbidity, Total Suspended Solids (TSS), Electrical conductivity (EC), Fecal Coliform, Phosphate, Nitrate, Nitrite, Ammonium, Dissolved oxygen (DO), pH, Chemical Oxygen Demand (COD) Biochemical Oxygen Demand (BOD) were measured. Habitat parameters such as Epifaunal Substrate (EFAC), Embeddedness (Embed), Velocity and Depth Regimes (Vel), sediment deposition (Sedimen), Channel Flow Status (Channelf), Channel Alteration (Channelt), Frequency of Riffles (Freq), Bank Stability (Bankstu), Vegetative Protection (Veg) and Riparian Vegetative Zone Width (RipaVeg) were reviewed. Then according to bioassessment protocols and ratings based on a zero to 20, for relationship between physicochemical and habitat parameters with an abundance of benthos grouping and assessment of water quality, from CANOCO software and principal component analysis (PCA) was used. The results showed that the water quality in the downstream Jajrud is unfavorable and appropriate management measures should be taken to improve the river's water quality.

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1. Introduction

Biomonitoring is necessary to evaluate the health of an ecosystem, considering the problems are ecological and necessary for human life. A biological survey can provide a comprehensive picture of the state of a condition in an ecosystem of a river (Ukasha et al., 2024). The evaluation of river conditions using biotic communities is based on the assumption that disturbances produce structural modifications in these communities, changing density and distribution or causing functional changes in the ecosystem. Organisms interact with numerous physicochemical conditions, showing their combined effects, and organisms accumulate these effects over time, indicating the ecosystem effects of water quality (Bio et al., 2011). Benthic macroinvertebrates are commonly used for assessment of biological water quality (An et al., 2002; Jessup et al., 2005; Alvarez-Cabria et al., 2010; Couceiro et al., 2012; Sundermann et al., 2013; Mehrjo et al., 2020; Hosseinabadi et al., 2022). One of the stages of their lives to spent in an aqueous environment and is seen with the naked eye (Rosenberg, 1999).

Usually, rivers are present, easily collected, not moving much and it is easy to detect kinship. Benthic can also show changes in water quality and as sensitive indicators of environmental change are used. The presence of pollution-resistant macroinvertebrates identified at the family level is related to water quality parameters and organic or inorganic pollutants (Hilsenhoff, 1997; Sinche et al., 2023). Using benthic macroinvertebrates based on the assumption that streams and rivers that are more influenced by pollution, and less diversity of resistant species are dominant (Davies, 2001; Mehrjo et al., 2020). Many studies have shown the use of benthic macroinvertebrates to evaluate water quality and the relationship between physicochemical and habitat parameters. Yazdani et al. (2014) investigated the relationship between benthic macroinvertebrate biological indices and water physicochemical parameters as a tool for water resource managers using principal component analysis (PCA), correlation analysis, and genetic programming (GP). The Margalf biological index was chosen as a suitable index for the studied watershed. The relationship found in this study for the first time between the biological index of Margalef and the physicochemical parameters of water in Aboulabbas River in Khuzestan province has been a useful tool for water resource managers to assess the state of the ecosystem over time. Bhadrecha et al. (2016), conducted a rapid integrated water quality assessment of the Mahiagar River using benthic macroinvertebrates and physicochemical parameters in India. The findings indicated that the water quality of the Mahiagar River was "slightly polluted" in the sampled locations. In addition, the results of the physicochemical analysis were also following the biological criteria of water quality established by the Central Pollution Control Board. Yorulmaz and Ertas (2021) assessed the water quality of Selendi River and the comparative performance of indicators based on benthic macroinvertebrates and physicochemical parameters in Turkey using Asterix software. The general method, cluster analysis (CLUS), and PCA analysis were applied to the physicochemical data set. The results showed that the Polish versions of BMWP, Spanish BMWP, Hungarian BMWP, Greek BMWP, and all versions of ASPT indices are more suitable for determining the water quality of Selendi River than FBI and BBI indices. Yongwei et al. (2023) investigated benthic macroinvertebrate community structure and water quality assessment in major rivers of Liaoning Province, China. In this river, the spatial distribution of community structure, the relationship between community structure and environmental factors, and the correlation between various evaluation indicators and environmental factors were analyzed. The results showed that large benthic invertebrates can be used as important indicators and their relationship with physicochemical and habitat parameters for the biological evaluation of water quality in the main rivers of Liaoning province. Multivariate statistical technique is used in environmental studies, including water quality, to identify relationships between factors, reduce datasets, and identify potential sources of contamination. In general, water quality can be determined based on techniques such as PCA analysis used to obtain independent principal components (Ibrahim et al., 2023). In this study, for the relationship between physicochemical and habitat parameters with an abundance of benthic macroinvertebrates and water quality assessment of Jajrud River through PCA analysis and software program CANOCO 5 was performed.

2. Material and Methods

2.1. Study Area

Jajrud River originated from the Elburz Mountains in northern Tehran. The source of drinking water in East Tehran and surrounding villages is in the river courses. On the other hand, because of the mountainous region and the problem of waste disposal, all wastewater from the surrounding villages, the river enters Jajrud. Also, along the river, solid waste and garbage disposal is seen (Kashefiasl and Zymdar, 2009). Jajrud River in recreational area is located annually and visited by many people from this region. Entry pollution caused by tourist places of villas around the river is one of the causes of pollution of the river. The protection of the Jajrud River as one of the five rivers protected in Iran as well role of the environment of aquatic ecosystems is an important issue. For sampling and assessment of water quality, of the 5 stations and during season four in 2013 from sampled downstream Jajrud (Fig. 1).

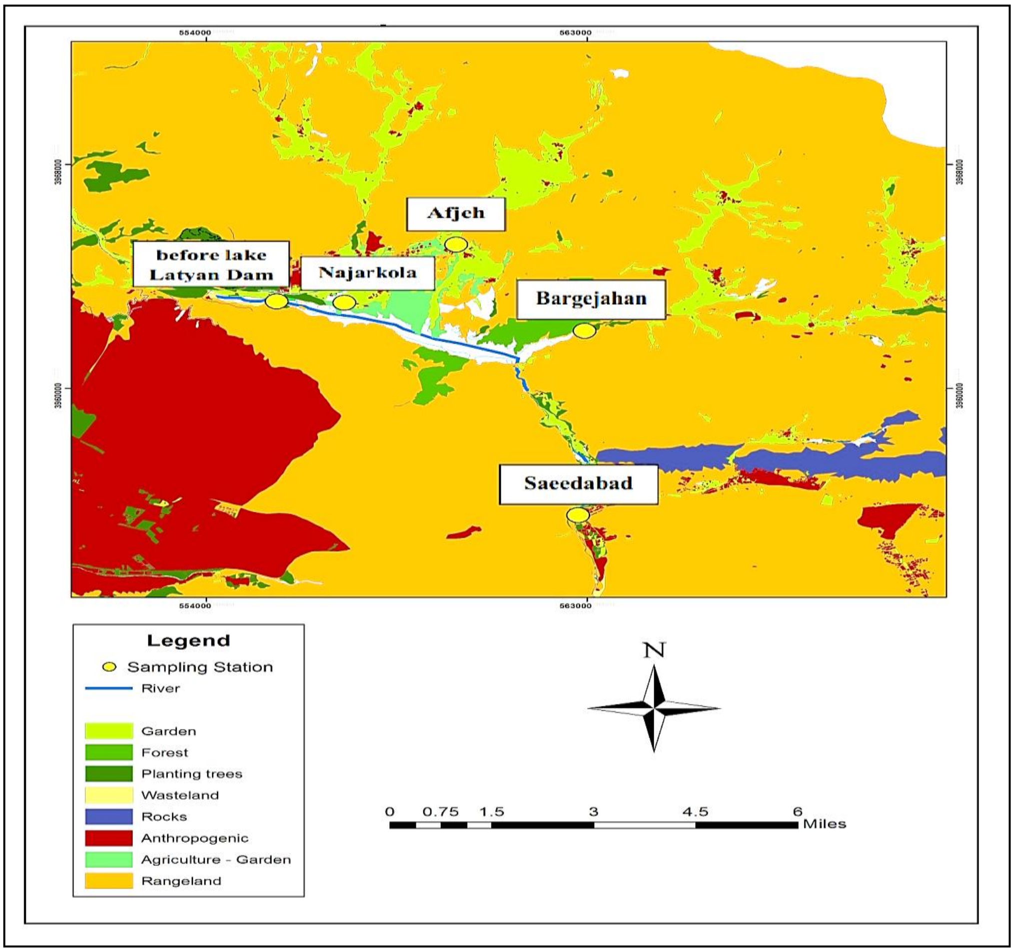

Fig. 1. Location of sampling stations in the study area

2.2. Benthic Macroinvertebrate Sampling

A sampling of Jajrud River benthic macroinvertebrate organisms from a Surber sampler device with an area of 900 cm^2 and mesh size of 250-micron and was repeated three times at each station. For this purpose, the Surber floor framework is in the opposite direction of the flow of the river bed, including stone, rubble, gravel, sand, and the bed of the river to wash, then benthic organisms by water flowing into Surber net guided. The contents of the Surber net into the pan are washed up and benthic organisms are removed from the river bed, then by pence and 250-micron sieve benthic organisms and benthic storage containers, and the river bed is thrown into benthic storage containers. The samples were fixed with formalin four percent were transported to the laboratory for isolation and identification. To separate benthic organisms, samples from a 250-micron sieve are then passed through the flow of water placed in formalin, and then washed up. The contents of the sieve containing benthic and river bed are poured into trays and benthic organisms under the microscope to identify and count moved. Using identify key benthic organisms (Tachet et al., 2000) identified and in level orders, families and genera mentioned. Aquatic insects make up the benthic percentage and families Baetidae, Chironomidae, and Heptagenidae the most frequent in were Jajrud. Based on tolerance value, benthic macroinvertebrates are into three groups sensitive (They increase the water quality is good), moderate (They increase the water quality is moderate) and resistant (They increase the water quality is poor) were classified (Bouchard and Paul, 2012). In Fig 2 shows some families of benthic macroinvertebrates identified.

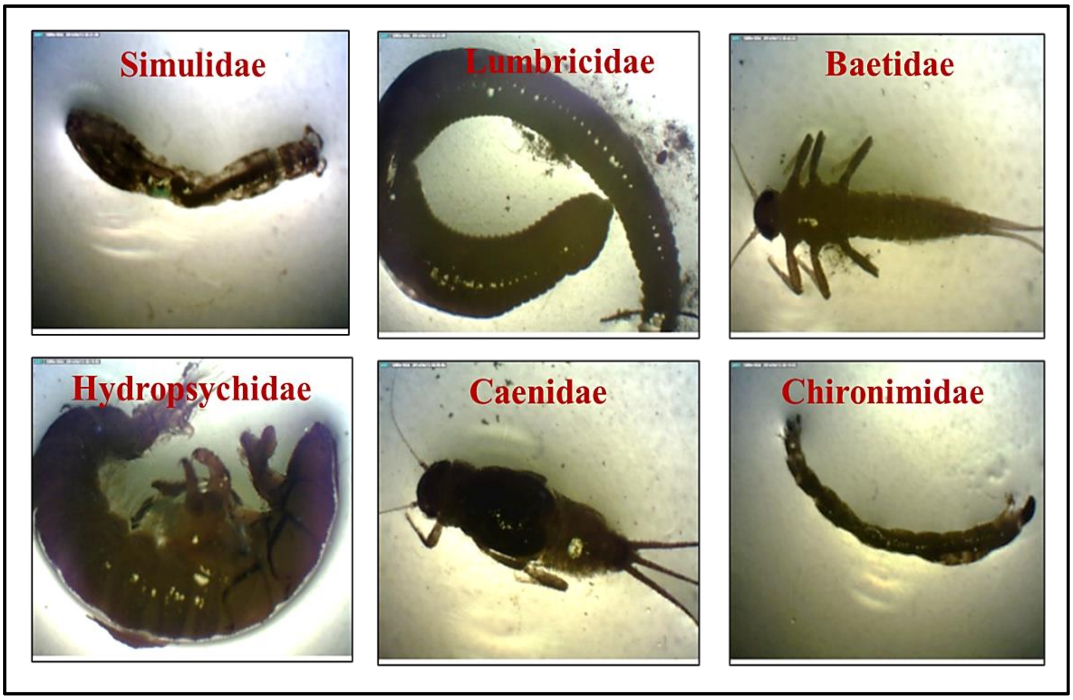

Fig. 2. Families of benthic macroinvertebrates identified (Source: Authors)

2.3. Physicochemical Parameters Sampling

Physicochemical parameters including Elevation, Depth, Flow Velocity (WatFlow), Water Temperature (WatTem), Turbidity, Total Suspended Solids (TSS), Electrical conductivity (EC), Fecal Coliform, Phosphate, Nitrate, Nitrite, Ammonium, Dissolved oxygen (DO), pH, Chemical Oxygen Demand (COD) Biochemical Oxygen Demand (BOD) Sampling and were measured.

2.4. Physicochemical Parameters Measuring

Dissolved oxygen (DO) and temperature parameters were measured at the sampling stations using a DO meter. After sampling from the river, the amount of BOD, and fecal coliform was transferred to the certified environmental laboratory and measured. The turbidity was measured with a turbidity meter, in this way, the device was first calibrated using special calibration glass cells, and then the sample was stirred and poured into a glass cell, which was covered with a napkin. It was cleaned and after mixing, it was placed in the turbidity meter chamber and the amount of turbidity was measured. The pH of the samples was measured using a pH meter in the laboratory. The concentration of nitrate, COD, nitrite, and phosphate was measured using a spectrophotometer. To measure the concentration of ammonia, first, the pH of the acidic samples was neutralized, then its concentration was measured using a spectrophotometer. To measure the total suspended solids (TSS), an oven, funnel, filter paper, Erlenmeyer, and petri dish were used.

2.5. Habitat Parameters Sampling

Habitat parameters such as Epifaunal Substrate (EFAC), Embeddedness (Embed), Velocity and Depth Regimes (Vel), sediment deposition (Sedimen), Channel Flow Status (Channelf), Channel Alteration (Channelt), Frequency of Riffles (Freq), Bank Stability (Bankstu), Vegetative Protection (Veg) and Riparian Vegetative Zone Width (RipaVeg) sampling according to rapid bioassessment protocols (Barbour et al., 1999) and ratings were based on a zero to 20.

3. Results and discussion

Due to the importance of rivers, ecosystem environment, and the role of biological indicators and benthic macroinvertebrates in planning and managing the quality of water resources, most of the rivers of developed countries are continuously evaluated and their physical, chemical, and biological characteristics are monitored (Yazdian et al., 2014; Muluye et al., 2024). For the relationship between physicochemical and habitat parameters with an abundance of benthos grouping, the software program CANOCO 5 and PCA analysis were used, Figs 3 to 6 are summarized for four seasons of sampling. The direction of the arrow indicates the direction influence. Each parameter that is the direction of the arrow with benthic macroinvertebrate grouping same direction shows a straight effect, and any parameter in the direction arrow its same direction of not show the conversely effect. The angle of the arrow indicates the severity of the influence. Whatever angle of arrow physicochemical parameters and habitat with benthic macroinvertebrates is less, are more strongly influenced and conversely. Also, the distance of the sampling stations is closer together, the condition is almost the same and conversely. The numbers 8 to 12 represent stations are sampled (Before Lake Latyan Dam=8, Najarkola=9, Afjeh=10, Bargjahan=11, Saeedabad=12). According to Fig 3, in the spring season stations 8 and 12 showed almost similar conditions. In a relationship, physicochemical parameters with an abundance of benthic macroinvertebrates can be expressed in the parameter’s turbidity, nitrite, elevation, nitrate, ammonium, TSS, and EC direct relation to each of the three groups benthic were and other parameters inversely relationship. Turbidity compared to other parameters has a greater impact on resistant taxa. The effect of nitrite on moderate and sensitive taxa has been noted more than other parameters. In most cases, human activities increase water turbidity, which causes significant ecological changes in short-term periods. The relationship between turbidity and the abundance of benthic macroinvertebrates can be unidirectional. In this case, such a relationship seems to be associated with the water turbidity threshold, after which the increase in abundance of large benthic macroinvertebrates stops and begins to decrease (Sosa-Aranda and Zambrano, 2019). Between habitat parameters Embeddedness and Bank Stability have a direct relationship with the three groupings of benthic macroinvertebrates and impact on the Embeddedness moderate taxon has more than others. Other parameters that have an inverse relationship to each grouping are benthic macroinvertebrates.

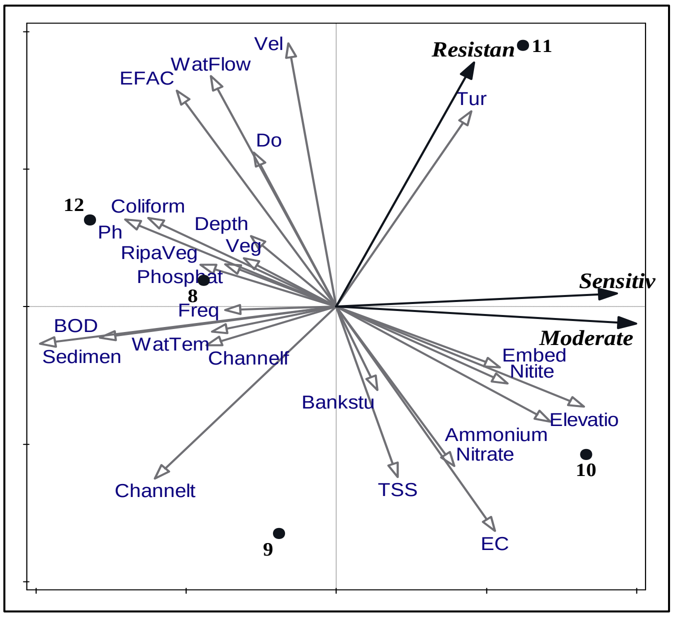

Fig. 3. Relationship between physicochemical and habitat parameters with benthic in spring season

According to Fig 4 in the summer season of sensitive and moderate taxa, the same conditions and parameters, DO, ammonia, and Channel Flow Status influence other parameters on these three groupings were benthic. The Embeddedness, phosphate, Elevation and BOD greater impact on taxa were resistant. A similar study by Efe et al. (2012) investigated the relationship between physicochemical parameters and benthic macroinvertebrates of the Ogunpa River in Nigeria. Benthic macroinvertebrates were classified according to their sensitivity to water pollution. High values of BOD and COD and the abundance of Chironomus (a pollution-resistant macroinvertebrate), indicated that the river was probably under pollution stress.

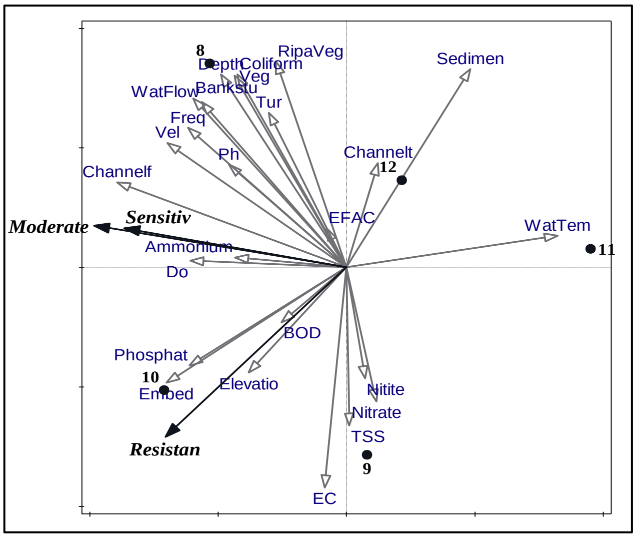

Fig. 4. Relationship between physicochemical parameters and habitat with benthic in summer season

According to Fig 5, in the autumn season, turbidity compared to other parameters has a greater impact on resistant taxa. Depth, Bank Stability, and ammonium had more impact on moderate taxa and impact depth was greater than the other two parameters. Ammonium, Elevation, Velocity, and Depth Regimes have more impact on the sensitive taxa than more than two parameters are and impact Elevation. The richness of Ephemeroptera, Plecoptera and Trichopera (EPT) species is significantly influenced by the bed and flow velocity in streams. In a similar study, Timm et al. (2008) examined the effects of habitat, season, and sampling effort on some common biological quality measures. It was observed that the highest species richness in sandy streams was not found on sand, but on dead leaves, wood and roots of alder, which confirms that the patchy structure is characterized in sandy rivers in front of rocks.

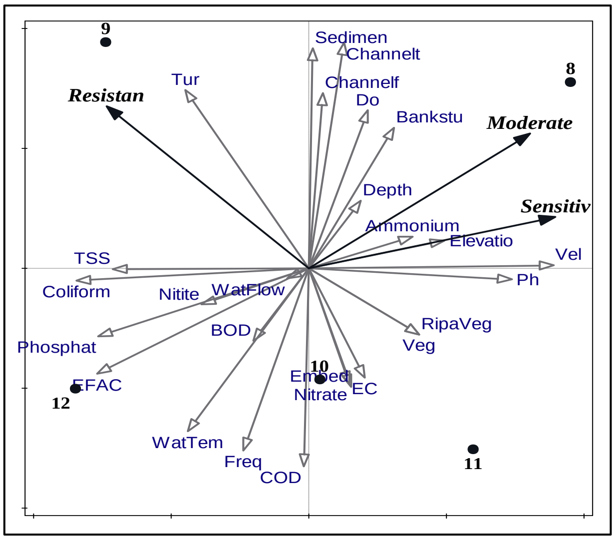

Fig. 5. Relationship between physicochemical parameters and habitat with benthic in autumn season

According to Fig 6 in winter season parameters turbidity, Embeddedness, Elevation, and pH were more effective than any other on moderate taxa that have been and impact more Embeddedness. Depth, fecal coliform, Velocity and Depth Regimes, and EC impression that an impact on the sensitive taxa Velocity and Depth Regimes has been more than other parameters. Parameters BOD, Vegetative Protection, Channel Flow Status, and Frequency of Riffles too more influence on that have been resistant taxa and impact than other parameters of the BOD. In similar research, the effect of seasonal variability on the development and application of a new multi-meter index based on benthic macroinvertebrate communities from streams of the Karun River Basin (Iran) was investigated by Ofogh et al. (2023). Physicochemical variables, physical habitat characteristics, and benthic macroinvertebrate communities were sampled and measured from 53 stream sites during four seasons. Based on the results of this study, the seasons with base flow (summer and autumn) were the most suitable for the development of several meters for water quality assessment. The main reason may be stability in the natural drivers (for example, stable river flows) that shape benthic macroinvertebrate community structure during these seasons.

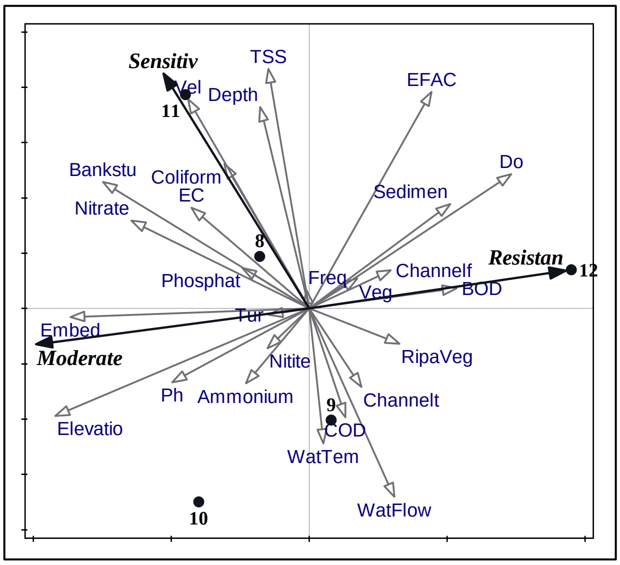

Fig. 6. Relationship between physicochemical parameters and habitat with benthic in winter season

4. Conclusion

Relationship physicochemical and habitat parameters with abundance of benthic in downstream Jajrud to PCA analysis during the season four and 5 stations were sampled. In the spring season with increase taxon resistant and water turbidity, water quality was poor. In station Bargjahan station (11) due to tourism along the river and dumping waste, cause pollution is river. In Afjeh (10) due to an increase in the moderate taxa and nitrite can be expressed as an average over the pollution of water quality assessment can be evaluated. In the summer season in Afjeh station (10) due to the increase BOD, phosphorus, change Embeddedness and resistant taxa water quality almost poor due to presence of tourists were at the station. Because increase sensitive taxa and moderate in station Before Lake Latyan Dam (8) and condition relatively good vegetation, the amount of dissolved oxygen and turbidity of water and somewhat stable river water, quality in the station can be assessed as moderate to good. In Najarkola station (9) because of construction garbage near the station was increased TSS. In autumn season, with increased taxa resistant in Bragjahan station also increased water turbidity. Because of construction residential areas and discharge sewage around the river are low the of water quality. In station Before Lake Latyan Dam (8) due to the increase in the moderate taxa, ammonia and changes around the river due to development villas in range station and construction of human water quality is somewhat lower. In station Afjeh (10) due to increase the diversity and sensitive taxa and also the vegetation cover, EC, Embeddedness and nitrate in moderate to good water quality can be evaluated. In season winter in Bargjahan station due to the increase sensitive taxa, Bank Stability and Velocity and Depth Regimes relatively good, water quality can be well seen in the station. In station Saeedabad (12) due to the increase levels of BOD and taxon resistant, water quality is low. Based on the evidence presented in studies stations downstream Jajrud can be said that this area is not having favorable conditions. Because of the importance river for drinking water supply in Tehran, must actions management and appropriate be taken to improve the water quality of the river.

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References

Alvarez-Cabria, M., Barquın, J. & Antonio Juanes, J., 2010. Spatial and seasonal variability of macroinvertebrate metrics: Do macroinvertebrate communities track river health? *Ecological Indicators*: 10, 370-379.

An, K.G., Park, S.S. & Shin, J.Y., 2002. An evaluation of a river health using the index of biological integrity along with relations to chemical and habitat conditions. *Environment International*: 28, 411-420.

Barbour, M.T., Gerritsen, J., Snyder, B.D. & Stribling, J.B., 1999. Rapid bioassessment protocols for use in streams and river: Pryphyton, Benthic Macroinvertebrates and fish, 2nd edition, EPA, 841–B-99-002 USEPA, Washington D.C. 408p.

Bhadrecha, M.H., Khatri, N. & Tyagi, S., 2016. Rapid integrated water quality evaluation of Mahisagar river using benthic macroinvertebrates. *Environmental monitoring and assessment*: 188(4), 254.

Bouchard, R.W. & Paul, J.S., 2012. Guide to Aquatic Invertebrate Families of Mongolia, Identification Manual for Students, Citizen Monitors, and Aquatic Resource Professionals, Minnesota, USA.

Bio, A., Vieira, N., Joao Costa, M. & Valente, A., 2011. Assessment of habitat and water quality of the Portuguese Febros River and one of its tributaries. *Limnetica*: 30(1), 103-116.

Couceiro, S.R.M., Hamada, N., Forsberg, B.R., Pimentel, T.P. & Luz, S.L.B., 2012. A macroinvertebrate multimetric index to evaluate the biological condition of streams in the Central Amazon region of Brazil. *Ecological Indicators*: 18, 118-125.

Davies, A., 2001. The use and limits of various methods of sampling and interpretation of Benthic Macroinvertebrates. *Journal of Limnology*: 60, 1-6.

Efe, O., Kokoette, E.I. & Alex, U.A.A., 2012. Physico-chemical parameters and benthic macroinvertebrates of Ogunpa river at Bodija, Ibadan, Oyo State. *European Journal of Scientific Research*: 85(1), 89-97.

Jessup, B., Moegenburg, S., Bryson, D. & Poretti, V., 2005. Development of the New Jersey Pinelands Macroinvertebrate Index (PMI), New Jersey Department of Environmental Protection P. O. Box 402 Trenton, NJ 08625-0402.

Hilsenhoff, W.L., 1977. Use of arthropods to evaluate water quality of streams. Tech. Bul. Wisconsin Dept. *Natural Resources*: 100, 15.

Hosseinabadi, F., Hashemi, S.H., Abdoli, A. & Mehrjo, F., 2022. Development of multimetric index based on benthic macroinvertebrate for water quality assessment of Jajrood River in Iran. *Caspian Journal of Environmental Sciences*: 20(1), 77-88.

Ibrahim, A., Ismail, A., Juahir, H., Iliyasu, A.B., Wailare, B.T., Mukhtar, M. & Aminu, H., 2023. Water quality modelling using principal component analysis and artificial neural network. *Marine Pollution Bulletin*: 187, 114493.

Kashefiasl, M. & Zymdar, M., 2009. Necessary management quality Jajrood River. Environmental Science and Technology, 6(2), 119-129.

Mehrjo, F., Abdoli, A., Hashemi, S.H. & Hosseinabadi, F., 2020. Development of a multimetric index based on benthic macroinvertebrates for downstream Jajrud in Tehran province, Iran. *Iranian Journal of Fisheries Sciences*: 19(1), 286-296.

Mehrjo, F., Hashemi, S.H., Abdoli, A. & Hosseinabadi, F., 2020. Taxonomy of benthic macroinvertebrates in Jajrud River for water quality assessment. *Environmental Resources Research*: 8(1), 1-10.

Muluye, T., Mengistou, S. & Fetahi, T., 2024. Assessing the ecological health of the upper and middle Awash River, Ethiopia, using benthic macroinvertebrates community structure and selected environmental variables. *Environmental Monitoring and Assessment*: 196(1), 45.

Ofogh, A.R.E., Dorche, E.E., Birk, S. & Bruder, A., 2023. Effect of seasonal variability on the development and application of a novel Multimetric Index based on benthic macroinvertebrate communities–a case study from streams in the Karun River basin (Iran). *Ecological Indicators*: 146, 109843.

Rosenberg, D.M., 1999. Protocols for measuring biodiversity: benthic macroinvertebrates in Freshwater. Department of fisheries and Oceans Freshwater Institute, Wainnipage, Manitoba, 42 p.

Tachet, H., Richoux, P., Bournaud, M. & Ussegio-Polatera, P., 2000. Invertebres D'eau Douce, systematique, biologie, ecologie.CNRS Edition, Paris.

Timm, H., Mardi, K.O. & Mols, T., 2008. Macroinvertebrates in Estonian streams: the effects of habitat, season, and sampling effort on some common metrics of biological quality. *Estonian Journal of Ecology*: 57(1).

Sundermann, A., Gerhardt, M., Kappes, H. & Haase, P., 2013. Stressor prioritisation in riverine ecosystems: Which environmental factors shape benthic invertebrate assemblage metrics? *Ecological Indicators*: 27, 83-96.

Sinche, F., Cabrera, M., Vaca, L., Segura, E. & Carrera, P., 2023. Determination of the ecological water quality in the Orienco stream using benthic macroinvertebrates in the Northern Ecuadorian Amazon. *Integrated Environmental Assessment and Management*: 19(3), 615-625.

Sosa-Aranda, I. & Zambrano, L., 2019. Relationship between turbidity and the benthic community in the preserved Montebello Lakes in Chiapas, Mexico. *Marine and Freshwater Research*: 71(7), 824-831.

Ukasha, T., Faisal, N.U.H., Adji, B.K. & Nugroho, A.P., 2024. Active biomonitoring in streams by using multimarker approaches of mussels. *Global Journal of Environmental Science and Management*.

Yazdian, H., Jaafarzadeh, N. & Zahraie, B., 2014. Relationship between benthic macroinvertebrate bio-indices and physicochemical parameters of water: a tool for water resources managers. *Journal of Environmental Health Science and Engineering*: 12, 1-9.

Yongwei, J.I.A.N.G., Zhenjun, D.I.N.G., Junbin, Y.U.A.N., Zheng, Z.H.A.N.G., Yang, L.I., Qingchun, W.E.N., Yeyao, W.A.N.G. & Xiaowei, J.I.N., 2023. Study on Benthic Macroinvertebrates Community Structure and Water Quality Evaluation in Main Rivers of Liaoning Province. *Ecology and Environment*: 32(5), 969.