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Qualitative and Quantitative Analysis of Planktons from Asan River, Dehradun, Uttarakhand

Dr. Banlumlang Lyngdoh Kynshi

Scholar, Department of fisheries Science (Aquaculture), Doon PG College of Agriculture and allied Sciences

Abstract
In this research, qualitative and quantitative analysis was done on the distribution of plankton communities with the aim of evaluating the health of Asan River in Dehradun, Uttarakhand. Some of the explored aspects included physicochemical properties of water, nutrient levels, phytoplankton species and heavy metals concentration by season. Work done identified a up surge and increase in contamination levels during summer and monsoon seasons. The values of DO appeared to be the lowest in summer (7. 71-9. 40 mg/L), while the BOD was the highest in summer (3. 43-4. 44 mg/L). The nutrient concentrations were high downstream reflecting the build-up anthropogenic effects. Diatoms were the most abundant phytoplankton in all the seasons especially in monsoon and post monsoon periods. There was a decline in the number and variety of insects in contaminated water and it was observed that the higher the accumulation of heavy metals the lesser the aquatic…
49. Heavy metal concentrations were inversely proportional with insects' biomasses in all the recorded water types. The present paper underlines the changes in hydrological conditions of the river following the seasonal variations as well as the impact of anthropogenic influences; therefore, more integrated assessment and conservation plans are required. Suggested initiatives are optimization of long-term monitoring programs, interventions regarding point and non-point source of pollution, application of several groups of bioindicators, increasing public awareness and concerns, and elaboration of climate change-sensitive policies. The findings of this research give useful recommendations of the Asan River ecosystem and other systems of water in the region.

Keywords: Asan River, plankton diversity, water quality, seasonal variation, anthropogenic impacts, bioindicators, heavy metals, phytoplankton, aquatic insects, river ecosystem management

Introduction
Rivers and wetlands as important ecosystems in the natural environment are capable to restoring the balance of various ecosystems and serve humanity in many ways. The Asan River one such water bodies which are significant for domestic, agricultural and industrial use as well as for the existence of aquatic life in Dehradun, Uttarakhand. However, due to increasing anthropogenic press such as urban water, industrial effusion and farming irrigation, pollution rate of the river is enormously high, which may lead to a threat to the river's health as well as bio-diversity (Chaudhary et al. 2024). This perhaps poses the

cyclic scenario of monitoring and analyzing the plankton communities of the river that is that planktons are sensitive barometers of the river's condition.

The review of literatures done in the current study shows that there is agreement with earlier authors such as Khanna et al. (2012) and Matta et al. (2018) to show that water quality parameters fluctuates with seasonality and to conform the effects of pollution on aquatic life. Moreover, Tabassum et al., (2024) have conducted the study on the analysis of heavy metal level and their impact on aquatic insects of Asan Wetland. Still, it revealed the requirement of further investigations to implement both qualitative as well as the quantitative evaluation of the plankton communities in order to determine the general conditions of the Asan River ecosystems.

Aims and Objectives

Aims

The main aim of this research is to establish a description of the plankton communities in the Asan River at Dehradun, Uttarakhand through qualitative and quantitative analyses. As a result, the purpose of this study is to evaluate the effects that seasonal fluctuations and pollution indices have on the river ecosystem for the purpose of strengthening protection and appropriate management. The specific objectives of this research are as follows:The specific objectives of this research are as follows:

Objectives

- To study the planktonic organism concentration and species richness.
- To evaluate anthropogenic impacts
- To explore ecological indicators
- To provide conservation recommendations

Literature Review

Pollution Levels

The study conducted by Khanna et al. (2012) kind of gives a broader picture of the Asan River and may help in understanding the fluctuations in water quality parameters in relation to the seasons. They were also able to identify the summers and the monsoon seasons as being the periods with the highest pollution level whereby the DO levels were significantly lower and bacterial counts were considerably higher than during other seasons. The study indicated DO levels base on this study it ranged between 7. 71 to 9. 40 mg/L, while the minimum concentrations were noted in warm time of the year. This seasonal distribution can be regarded as typical because microbial activity as well as the solubility of oxygen in the water decreases at elevated temperatures. Yet the authors could give more specific discussions on these seasonal fluctuations which possibly resulting from the flow of river or human activities.

Matta et al. (2018) built on this approach to study the Ganga River system but with 10 sites with sampling occurring over to encompass the entire year. Khanna et al also described the seasonal trend and S.Gopinathan confirmed this by stating that the nutrient levels and the degree of turbidity were high in monsoon and post monsoon periods. It is noteworthy that the values of turbidity provided by them varied between 5. 31 to 593. 31 NTU, and average was highest during the monsoon period. In this case therefore, more specific information on the temporal and spatial distribution of water quality is obtained. The authors successfully associated these changes to such natural conditions as rainfall and fluctuations in water levels and such man-made causes as agriculture and sewage effluence. However, the study could have done with better development of what kind of ecological implications may arise from such variations.

With regards to this, Tabassum et al. (2024) solely concentrated on heavy metal pollution in the Asan Wetland hence giving more of an insight on this aspect of water quality. This is in concordance reported of their findings of higher heavy metal concentrations during monsoon and summer seasons as seen in the other studies.

For example, in relation to heavy metals, they indicated that lead concentration reached the highest level of 0. 576 mg/L and arsenic at 1. This periodicity of the pollutants and water bodies points towards a rather rigid seasonal variation in the quality of water in the region. The authors' utilization of sophisticated regression models to hence predict a relationship between the heavy metal concentration and the density of aquatic insects is encourages, although the authors could have examined the possible pathways in the relationship more elaborately.

Phytoplankton Diversity

The study done in the March and April month of the year by Neg et al. (2013) revealed the presence of 36 genera of phytoplankton in streams at Dehradun city and 42 genera. Their observation of Bacillariales (diatoms) being the most abundant order is a typical sequence of the river phytoplankton community. However, the openness of the research to newly appointed managers and the relatively short data collection period of two months reduces its capacity in determining more extensive seasonal patterns and trends. Also, the authors could have made it better if they described the ratios of different taxa and how much of each were existent in the samples mentioned.

Matta et al. (2018) provided a better description of phytoplankton communities in his Ganga River study. The researchers also identified diatoms as the most diverse of the two groups, and the second and the third priority included green algae and blue-green algae, respectively. The authors specified six main diatom genera and stated that the phytoplankton density was generally higher at the downstream stations, and the maximal density was 3126 ind./L. In this structure, spatial pattern might be associated with nutrient enrichment in lower reaches of the river. Due to the fact that the study lasted for a whole year, and collected samples from multiple locations, the study offers a sufficient data to explain the patterns of phytoplankton. Nevertheless, the authors could have enriched their study by investigating relationships between the diet composition and several water quality variables.

To be precise, Tabassum et al, (2024) adopted a novel strategy of witnessing the bioindicators in the Asan Wetland amongst the aquatic insects. They were able to classify thirteen genera coming from six orders and found out that there was a distinct seasonal preferences of the dipterans to the environment they were studying.

The study presents an extensive approach to exploring patterns of insect communities in relation to environmental parameters by using two diversity indices (H', Margalef'), besides conductance multivariate statistics CCA and PCA. For example, they established that the level of Shannon-Wiener diversity index variation could vary from 0. 9557 to 2. 461 across sites and seasons, the lowest values are presented in July consistently. It offers understanding of the top organizations of the aquatic community and showed that aquatic insects could be used as potential bioindicators of stress. Nevertheless, in this study it could have been useful to provide a deeper analysis of the behaviors and necessities of habit of the insect taxa pointed out.

Human activities and conservation perspectives

Each of the four works demonstrates the critical state of these aquatic systems due to anthropogenic impacts despite of the fact that the authors pose the problem in quite different ways. Khanna et al. (2012) concentrated on bacterial indicators of pollution and got the total coliform counts between 354 and 617 MPN/100ml throughout the seasons. These higher figures, especially in the course of warmer weather, indicate high bacterial pollution, most probably sewage dumping. These data were used quite passionately by the authors for promoting better and sustainable wastewater management in the region.
Thus, Matta et al. (2018) gave a larger vision of anthropogenic effects in distributing a broad array of nutrients and pollutants. They were found to be slightly higher and ranged from 0. 181 mg/L of phosphates and 0. 063 mg/L of nitrates downstream sites suggesting that these are accumulated impacts of agricultural runoff and Urban effluents. Based on the above results, the authors computed a WQI which during monsoon (161. 29) and post monsoon (142. 37) seasons was above the acceptable limit. This approach could successfully combine several parameters into one index of the ecosystems' health, Though, the authors could have supplied more details about the relevance of these WQI values in terms of ecosystem.

Research Methodology

This work operates on positivism since it deals with statistics and other objective measures to assess the ecological status of Asan River. The methodology is geared towards the systematic and scientific acquisition of information and is designed in a manner that allows the identified results to be empirical and refritable.

Qualitative and Quantitative Analysis

Thus, the study aims at conducting a qualitative and quantitative analysis of plankton communities in Asan River in order to determine their richness and distribution. This approach means that one can work in detail on the ecology dynamics and easily come across the pattern and trends which cannot easily be observed under quantitative methods.

Deductive Approach

This type of research is deductive, as it covers the practical aspects of water quality and plankton diversity, defined by hypothesis and prior studies. These hypotheses are to be tested by data collection and analysis that form the framework of investigation into aquatic systems, with Water Quality Parameters and Pollution Levels Plankton Communities.

Data Collection

Sampling is done afield and cross-sections of the Asan River are chosen with an aim sampling different seasons with the view that this will capture temporal variability. These constituents are dissolved oxygen, biochemical oxygen demand, nutrient and heavy metals in water samples (Malik et al. 2023). Samples of plankton are obtained using plankton nets and the samples collected are normally preserved so that they can be taken to the laboratory for processing.

Thematic Analysis

To examine the data, thematic analysis is used which aims at categorizing the patterns of the qualitative data. This entails assigning different numbers to various code of the data regarding water quality, plankton Biodiversity and pollution effects. The thematic analysis makes it possible to determine the repeated themes and tendencies that can give valuable information concerning the ecological situation in the region of the river.

Data Analysis

Correlation analysis is conducted to study the correlation between different water quality indices and the plankton species richness. This means that thematic analysis results are then merged with quantitative analysis results, in order to create a vast synthesis of the data received.

Findings and Discussions

Water Quality Parameters and Seasonal Variations

Khanna et al. (2012) and Matta et al. (2018) works are valuable to understand the fluctuation of water quality parameters in Asan River and Ganga River system by seasons. What both studies have found is that winter had lower rates of pollution but they also both noticed heightened pollution in the summer and monsoon seasons.

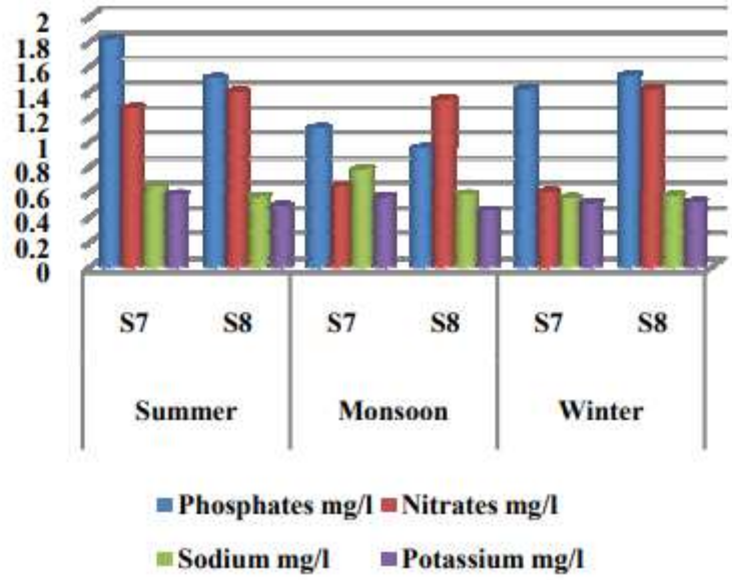

Figure 1: Average Sesonal variation

(Source: Khanna et al. 2012)

Khanna et al. (2012) also described DO profiles which indicated the Asan River DO was lowest in summer varying between 7. 71±0. 63 to 9. 40±0. 45 mg/L. This seems to be the case in the decrease in DO during the warmer parts of the year since microbial activity is higher and temperatures lower levels of oxygen dissolving capacity. On the other hand, the analyzed water sample was characterized by significantly higher values of biochemical oxygen demand (BOD), The rising BOD of the water sample was observed to increase in summer and had a range of 3. 43±0. 20 to 4. 44±0. The outlet's BOD value is 38 mg/L while the conventional value is 25 mg/L, which suggests high levels of organic pollution. These findings indicate that, river has lost the capability of self-purification especially in warmer months of the year probably due to high levels of anthropogenic load and reduced flow in the river.

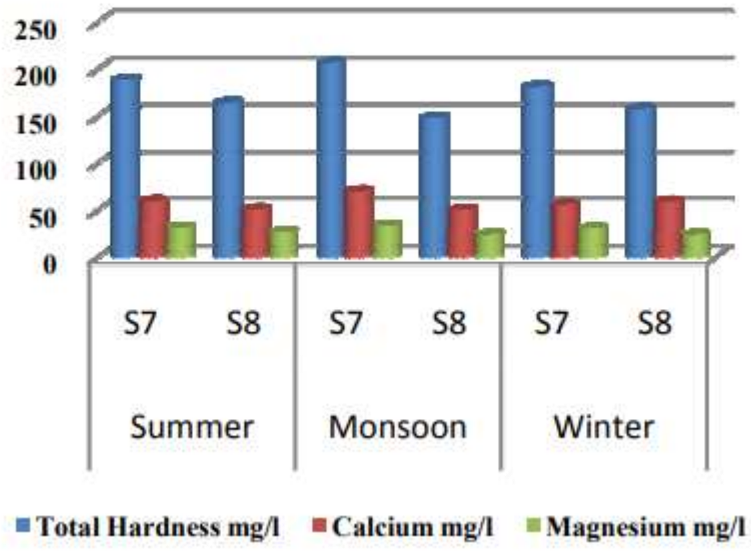

Figure 2: Average Sesonal variation
(Source: Khanna et al. 2012)

Matta et al. (2018) noted similar ampliation for DO in the Ganga River system with its level stayed above 6 mg/L that is the recommended DO in drinking water standards throughout the year. But, during the monsoon period, they pointed increased turbidity, TSS, and TDS concentrations (Tomar et al. 2022). For instance, maximum turbidity was recorded to 593. 31 NTU at one site during monsoon though it was as low as 5 at other site. 31 NTU during post-monsoon. Higher concentration of TSS during monsoon period can therefore be explained through runoff and erosion that directly affect the water quality affects ability of water to transmit light of photosynthetically active radiation and might transport pollutants.

Nutrient Dynamics and Eutrophication Indicators

As for the nutrient concentration, Matta et al. learned a great source of data from both Khanna et al. and analyzed the aspects of the nutrient concentrations in their study areas. Matta et al. (2018) also observed the concentration of nutrient is more at downstream sites in Ganga River system and the chloride (5. 81 mg/L) and nitrate (0. 063 mg/L) found more at Site 1 in monsoon and post-monsoon seasons. They also determined maximum concentration of phosphate at Site 4 as summer, with a concentration of 0.181 mg/L. Such high nutrient concentrations particularly in the downstream sites, indicate the compiled effect of anthropogenic activities along the river. As per Khanna et al. (2012) the similar results were found where the Asan River contaminated with high amount of phosphates and nitrates during summer and monsoon season. He said that they blamed this surge in pollution to the disposal of seepage, industrial wastes, and water used in the cultivation of crops. These higher nutrient concentrations were found by the authors to be capable of promoting algal growth and thus possibly causing eutrophication.

Table 1: Comparison of key water quality parameters across studies

Parameter	Asan River (Khanna et al., 2012)	Ganga River System (Matta et al., 2018)
DO (mg/L)	7.71±0.63 to 9.40±0.45	>6 (all sites)
BOD (mg/L)	3.43±0.20 to 4.44±0.38	0.68 to 3.76

NO3- (mg/L)	Not reported	0.063 (max at Site 1)
PO4-3 (mg/L)	Not reported	0.181 (max at Site 4)

Phytoplankton Diversity and Distribution

The study was preceded by the works of Neg et al. (2013) and Matta et al. (2018) who described the phytoplankton communities in the study area. Neg et al. (2013) found that in March the genus composition of butterflies amounted to 15, 36 genera were found of which 15 families and 6 orders and in April 42 genera of which 18 families and 8 orders. The increase of phytoplankton diversity from March to April also implies seasonal dynamics in terms of community changes because of temperature and nutrient fluctuations.

S.No	Phytoplankton taxa	March,2013			April,2013		
		(S - I)	(S-II)	(S-III)	(S-I)	(S -II)	S- III
(A)	***Order – Bacillariales***						
(a)	***Family-Fragilariaceae***						
1	*Ceratneis*	+					
2	*Diatoma*		+				+
3	*Fragilaria*	+			+		+
	Subfamily- Meridioniodeace						
	Meridion				+		
(b)	***Family – Eunotiaceae***						
1	*Actinella*	+				+	+
2	*Eunotia*		+	+			+
3	*Peronia*	+			+		
(c)	***Family – Achnanthaceae***						
1	*Eucocconeis*			+		+	
	Rholocosphenia						
(d)	***Family – Naviculaceae***						
1	*Amphipleura*	+		+		+	
2	*Anomoenesis*						+
3	*Brebissonia*	+	+	+	+	+	
4	*Caloneis*				+	+	
5	*Diatomella*	+		+	+		
6	*Frustulia*			+	+	+	
7	*Gyrosigma*		+		+	+	
8	*Navicula*	+				+	
9	*Pinnularia*					+	
10	*Stauroneis*		+				
(e)	***Family – Cymbellaceae***						
1	*Amphora*		+		+	+	
2	*Cymbella*		+	+	+		+
(f)	***Family – Epithemiaceae***						
1	*Denticula*	+					
2	*Epithemia*		+	+	+		
3	*Rhopalodia*		+	+	+	+	+
(g)	***Family – Nitzschiaceae***						
1	*Bacillaria*	+				+	+
2	*Nitzschia*		+				
(B)	***Order – Chlorococcales***						
	Family- Chlorococcaceae						
	Chlorococcum						+
(h)	***Family – Oocystaceae***						
1	*Chlorella*	+		+	+		
2	*Closteriopsis*		+	+	+		+
(i)	***Family – Mesotaeniaceae***						
1	*Roya*	+		+	+	+	
(j)	***Family – Desmidiaceae***						

Figure 3: Phytoplankton Diversity

(Source: Neg et al. 2013)

As in Matta et al. (2018) in Ganga River system, diatoms dominated and was followed by green and blue-green algae. They identified six notable diatom genera: Such important genera of Diatoms include; Diatoma, Fragilaria, Gomphonema, Amphora, Cymbella, and Achnanthes. The authors gave clear population densities of these genera for various seasons, and it was observed that higher densities are during monsoon and post monsoon (Kaur and Naseer, 2023). For instance, Fragilaria exhibited the average of 222 densities. 50±123. L were identified during monsoon period out of which 15 and the annual average of 232 people per lakh population were died. 50±155. 79 individuals/L during post-monsoon.

Table 2: Comparison of phytoplankton diversity across studies

Study	Total Genera	Dominant Groups	Notable Findings
Neg et al. (2013)	36 (March), 42 (April)	Bacillariales (diatoms)	Increase in diversity from March to April
Matta et al. (2018)	Not specified	Diatoms, Green algae, Blue-green algae	Highest diatom densities in monsoon and post-monsoon

Heavy Metal Contamination and Aquatic Insect Biodiversity

Tabassum et al. (2024) presented a different view by analyzing the direct association between the impact of heavy metals and the benthic macroinvertebrate index of the Asan Wetland. They established that the quantities of heavy metals were highest during the monsoon season, then during summer and lowest during winter. For eg, they mentioned that the cadmium was found to be at max in August with a value of 0. 0853±0. 0457 ppm and similarly for copper with 0. 192±0. 168 ppm, for arsenic it was 1. 03±0. 0783 ppm, and for lead it was 0. In the present investigation, the authors recognized 13 genera of the aquatic insects comprising six orders with seasonal fluctuations separately. With respect to these variations, the authors employed some diversity indices (Shyam et al. 2020). For instance, the Shannon-Wiener diversity index was high in winter; it reach 2. 461 at Site 3 in January and low during monsoon; which was 0. 9557 at Site 3 in July. Given the negative correlation of the heavy metal concentrations in the water with the number of the aquatic insects, the authors propose the metal pollution of the studied water bodies to be the cause for decrease of these bioindicators.

Critical Analysis and Implications

Temporal and Spatial Variability: The literature survey suggests that there are marked seasonal fluctuations in operational water quality characteristics and the concentrations of nutrients and the biotic index values (Purohit and Joshi, 2023). This emphasizes the need to have monitoring programs that be able track these temporal changes. Moreover, the differences highlighted with regard to spatial aspect, which were clearly expressed, for instance, in the Ganga River system study by Matta et al. (2018) underline the necessity of using a number of sampling sites in order to properly evaluate the condition of a river.

Anthropogenic Impacts: Several works, whether current works or works written in the past, indicate that human beings have had a big impact on the river systems. The manifested variation of nutrient levels, BOD and heavy metal concentration during monsoon and summer season advocating the runoff from agricultural fields, urban and industrial area has a greater influence on the water quality (Sharma and Sharma, 2021). This emphasizes the need to apply watershed management solutions that take into account point and non point sources of pollution.

Bioindicators: This cannot be underemphasized as the studies show the importance of the multiple bioindicators when it comes to attaining ecosystem health. Whereas, Neg et al. (2013) and Matta et al. (2018) dealt with phytoplankton assemblages, Tabassum et al. (2024) assessed aquatic insects. All the strategies provide different perspectives of the ecosystems' reaction to the stress factors. Properly the next steps could be taken in order to develop these bioindicators' usage for ecosystem health evaluation; the proper approach could be to proceed with the study of various groups of bioindicators simultaneously.

Ecosystem Services and Human Health: The results showed that some of these river systems have issues pertaining to water quality such as high nutrient concentrations and heavy metals concentrations and thus questions the productivity of these river systems in terms of the ecosystem services that they offer (Tiwari, 2020). The high nutrient concentrations indicate that eutrophication could be a serious issue, and therefore threaten the rivers' capacity to foster rich aquatic life, and furnish water in its purest form to the people. Besides, there are potential dangers concerning activities that include heavy metals at some concentrations exceeding the benchmarks for safety, dangers affecting not only aquatic life but also the inhabitants of Anglo American.

Climate Change Considerations: Although none of the studies was done with regard to climate change, the patterns and fluctuations observed in water quality and biological state may indicate the system's sensitivity to climate change indicators, such as increased or altered temperature or variation in precipitation levels (Mehra and Arya, 2022). Additionally, future research should embrace the ideas of climate change and project future conditions in order to estimate the sustainability of the aquatic ecosystems.

Conclusion

The rich and detailed qualitative and quantitative data of plankton communities in the Asan River Dehradun, Uttarakhand informs novel lessons about the health of the river's ecosystem and changes due to seasonal variations and other pollutants. From the discussed works we can summarize that water in the Asan River is sensitive to anthropogenic impacts and depending on the season which in this case are summer and monsoon the levels of pollutant are high. The level of nutrient, heavy metal and dissolved oxygen also reflect the poor productivity of the river to sustain the variety of aquatic life and water quality.

According to the study, the taxonomical composition of phytoplankton species mainly due to diatoms is vary in the different season, the highest average abundance is measure during monsoon and post monsoon periods. The results from the heavy metal concentrations and aquatics insects also support the impacts of pollution and biotic structures. With water quality problems observed to be very rampant in the different river systems in the region, there is need to address various sources of pollution and also promote the right measures of water conservation.

Recommendations

To Enhance Monitoring Programs: Implement more sustainable long-term surveillance projects for temporal and spatial changes in the values of the water quality characteristics and plankton populations (Matta et al. 2020). Field protocols for water quality and biological surveys should be compiled to enhance efficient comparison of results of different analyses and at different time.

To Address Anthropogenic Pollution: Hire and employ desperate watershed programs that act in point and non-point sources of water pollution (Sharma and Sharma, 2021). Such measures include, rehabilitating and expanding wastewater treatment plants, controlling emission and discharge of pollutants from industries and encouraing use of methods that prevent contamination of water sources fr om agricultural activities.

To Utilize Bioindicators: Analyse more than one bioindicator group as phytoplankton and aquatic insects in order to best assess the health state of the ecosystem (Singh et al. 2023). They should also be noted that bioindicators can highlight the situations when the water quality is impaired and timely remedial actions should be taken.

To Promote Community Involvement: Use community engagement approach and mobilize the local people on the need to conserve the rivers (Rana et al. 2024). Through educational programs and community based monitoring it makes people develop a stewards' mentality for the environment and enhance sustainable practices.

To Conduct Further Research: This study should be followed by further research that would analyse the effects of climate change on the Asan River ecosystem (Rashid and Majeed, 2022). There is little information concerning the resistance of the aquatic habitats and communities for climate change patterns in the long-term and therefore it is crucial to include climate projections to long-term studies.

To Develop Policy Frameworks: It is suggested that some new rigorous rules or regulations should be made regarding pollution and should be implemented to minimize the pollution level of the Asan River (Sharma and Sharma, 2022). They should be directed towards the conservation of ecosystems, the support of biological diversity and the guarantee of supplying ecosystem goods and services.

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