Short Research Article

An Assessment of the Environmental Impacts of Catchment Management on the Status of Pong Wetland in District Kangra of Himachal Pradesh

Nancy Loria[1*], K. S. Verma[2] and S. K. Bhardwaj[1]

[1]Dept. of Environmental Science Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. (173 230), India

[2] Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. (173 230), India

Abstract

The study on the environmental impacts of catchment management on the status of Pong wetland was conducted during the year 2011-12 in the immediate catchment of Pong reservoir. Four main tributaries viz., Buhal, Dehar, Gaj and Banerwere selected to determine spatial trends in nutrient concentrations and to relate these trends to different land use systems in the catchment. Each tributary was divided into four sites of 5 km each. Site which does not form the catchment of Pong reservoir was excluded. Nutrient concentrations at most of the sites within the catchment were found within the permissible limits. However, no spatial trend was observed along a longitudinal gradient in the nutrient concentrations of tributaries taken under study. Spatial distribution of land use system in the catchment of wetland corroborated that catchment under study covered maximum area under forest land use followed by cultivated land and barren land. Three representative samples of silt at different locations were collected from the lake at the point of their entry into the lake and were used to analyze for certain heavy metals like Cd, Fe, Cu, Zn. Silt characteristics of lake were showed that lake sediments contain heavy metals but ranged within the permissible limits. However, increase in their concentration in near future may cause changes in the physico-chemical composition of the lake water. Improved management and maintenance of catchment land use systems are crucial and there is a need to conserve and preserve these existing wetlands to maintain and improve the ecological balance.

1. Introduction

The Pong wetland located in the Kangra District of Himachal Pradesh has been declared 'Ramsar site-wetland of international importance' and formed by the construction of Pong Dam during 1975 across the Beas River. It is one of the largest man-made wetlands of the northern India. State owned; the Beas Bhakhra Management Board (BBMB) controls the reservoir, and the H.P. State Forest Department, the catchment area. Fishing and cultivation along the shoreline are a source of some disturbance and the most serious threat comes from the exploitation of catchment resources by humans. The losses of wetlands caused by agriculture are largely attributed to the drainage and conversion of wetlands to croplands, increased rates of sedimentation due to soil loss within catchments, reduced stream flow from dam building and abstraction, the spread of alien invasive plant species and poor management

of burning and grazing. Draining and converting wetlands to croplands has been well demonstrated to have high impacts on wetland characteristics and functioning (Willrich and Smith, 1970; Kotze and Breen, 2000). The wetland's ability to attenuate and purify storm flow is greatly reduced, with subsequent impact on downstream water users such as humans or other aquatic systems. The complete loss of wetland habitat is associated with the conversion to croplands. Drainage can also negatively affect dry season water flow and supply (Roggeri, 1995). This can have serious effects on downstream biota and on water quality through the concentration of pollutants. The destruction of wetlands and riparian zones increases sediment movement via streams, with the sediment diminishing habitat diversity and destroying ecological corridors in the landscape. The streams in connected wetlands deposit increased sediment loads, which results in severe environmental damage (Junk, 2002). Recognizing that wetland is strongly influenced by the

management of their catchments from which it receive water, the study was conducted with the objective to determine spatial trends in nutrient concentrations of streams connected to wetland and to relate these trends to different land use systems in the catchment.

2. Materials and Methods

2.1. Study site

The Pong dam reservoir extends between latitudes 31°49′ to 32°14′ North and longitudes 75°53′ to 76°17′ East. The altitude varies between 335-435 m msl. The climate of the Pong Dam Lake is typical of the northern India i.e. sub-tropical. Predominant land use systems practiced by the catchment inhabitants are agriculture, pasture and forestry. Fishing and cultivation are two main shoreline activities affecting the health of aquatic ecosystem.

2.2. Method of data collection

For conducting present study, sampling for water was done during the month of October and November in the year 2011 from the immediate catchment of Pong reservoir. Further analysis of the water samples was carried out in the laboratory of Department of Environmental Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh, India) during the year 2012. The actual study area comprised of catchment upto 20 km distance from the reservoir. The four main tributaries viz., Buhal, Dehar, Gaj and Baner those directly drains into Pong reservoir were selected for the study. Each tributary (upto 20 km from the reservoir) was divided into 4 sites such that each covers 5 km i.e. S_1 (0-5 km), S_2 (5-10 km), S_3 (10-15 km) and S_4 (15-20 km). In this way number of sites formed for water sampling were 15 as one site of Buhal tributary was excluded because it does not form the catchment of Pong reservoir. Random sampling of water quality was conducted at these sites along a longitudinal gradient in the four main tributaries. Collected water samples were analysed for pH (glass electrode method), electrical conductivity (glass electrode method), suspended and dissolved solids (gravimetric method) and other parameters like potassium and calcium were estimated using flame photometer. Magnesium, sodium, chlorides, sulphates and phosphates were estimated spectrophotometrically by using Spectroquant Pharo 300 (APHA, 1998).

Data regarding status of catchment upto 20 km distance from the Pong reservoir was obtained from the Department of Agriculture. Field survey 2007-2008 conducted by Dept. of Agriculture (2009) in their District Agriculture Plan (DAP):Kangra, H.P., Vol. IV has shown block wise land utilization pattern in the district Kangra. The data obtained from such survey was used to have the estimate of land use pattern

covered under study area within different blocks (Table 1). Blocks which were coming within 20 km aerial stretch from Pong Wetland were covered under study. The rough estimate of the study area within different blocks was made using the district map scale (1 cm=1.2 km). Then the percentage of study area from total geographical area within different blocks was calculated and further land use pattern within different blocks on the basis of percentage given in DAP Plan was calculated.

Three representative samples of silt of different locations were collected from the lake at the point of their entry into the lake. After collection, samples were air dried in shade, ground with wooden pestle mortar, passed through 2 mm sieve and stored in cloth bags. These sieved samples were then digested using method as prescribed by Saison et al. (2004) to estimate certain heavy metals like Cd, Fe, Cu, and Zn and then analysed in Inductively Coupled Plasma Analyzer (ICPA).

3. Results and Discussion

3.1. Spatial trends in nutrient concentrations

Data presented in Table 2 revealed that S_1 site of Buhal tributary showed the maximum values for total suspended solids (TSS) , magnesium (Mg), chloride (Cl⁻) and sulphate (SO_4^{2-}). S_2 Site showed maximum values for total dissolved solids (TDS) and potassium (K). S_3 site of Buhal tributary showed highest values for pH, electrical conductivity (EC), Ca, Na and phosphate (PO_4^{2-}).

Data presented in Table 3 revealed that S_1 site of Dehar tributary showed the maximum values for pH, TSS and phosphate. S_2 site showed maximum values for K and Ca. S_3 site showed highest value for electrical conductivity. S_4 site of this tributary resulted in maximum values for TDS, Mg, Na, chloride and sulphate.

Data presented in Table 4 revealed that S_1 site of Gaj tributary has greater pH, TSS, Ca, Mg and chloride values in comparison to other nutrients. S_2 site showed maximum values for TDS and sulphate. S_3 site showed highest value for EC, K and Na. S_4 site of this tributary resulted in maximum values for phosphate.

Data presented in Table 5 revealed that S_1 site of Baner tributary showed the maximum values for TSS, Ca and phosphate. S_2 Site showed maximum values for pH and Na. S_3 site showed highest values for chloride and sulphate. S_4 site of this tributary resulted in maximum values for EC, TDS, K and Mg.

The tributaries of pong wetland revealed in the results that pH for all sites was above 7 and pH values generally increased from the neutral to alkaline range. Electrical conductivity was due to the presence of salts in the tributaries. In Kawar Lake, India, a similar range of conductivity has been recorded, George (1962). The total dissolved solidsin tributaries were

Table 1: Spatial distribution of land use systems in catchment* of Pong dam reservoir (km²)

Blocks		Fateh-pur	Nurpur	Nagrota Surian	Rait	Kangra	Dehra Gopipur	Total
Total geographical area		75.24	140.94	372.68	148.8	159.23	34.15	931.04
Forests	Productive	10.46	47.05	140.93	0	71.86	6.55	276.85
	Degraded	3.30	0	0	37.35	0	0	40.65
	Total	13.76	47.05	140.93	37.35	71.86	6.55	317.5
Barren land (Rocky)		0.77	12.54	20.21	73.05	7.12	10.68	124.37
Land put to non-agricultural uses	Buildings	1.78	11.57	27.23	2.31	14.49	3.81	61.19
	Roads/paths/channels	5.79	0	0	1.73	0	0	7.53
	total	7.57	11.57	27.23	4.04	14.49	3.81	68.72
Culturable waste	Weed/bush infested	6.82	3.17	18.03	2.45	3.17	0.85	34.49
	Area prone to animal menace	6.55	3.49	0	1.15	0	0	11.2
	Total	13.37	6.66	18.03	3.60	3.17	0.85	45.69
Permanent pastures and other grazing lands	Productive	5.85	2.3	13.46	0.0020	12.51	3.15	37.29
	Degraded	4.24	0	0	0.0052	0	0	4.25
	total	10.09	2.3	13.46	0.0072	12.51	3.15	41.54
Miscellaneous trees and groves		3.48	0.52	19.16	1.43	8.55	1.34	34.48
Fallow land	Current fallow	0.22	2.09	13.44	0.22	1.62	0.98	18.57
	Other fallow	1.23	0	23.46	0.57	0	0	25.26
	Total	1.45	2.09	36.9	0.79	1.62	0.98	43.83
Cultivated land		24.73	58.17	96.76	27.48	39.90	6.81	253.85

Table 2: Spatial trends in nutrient concentrations for Buhal tributary

Parameters	pH	EC (mmhos cm⁻¹)	TDS (mg l⁻¹)	TSS (mg l⁻¹)	K (mg l⁻¹)	Ca (mg l⁻¹)	Mg (mg l⁻¹)	Na (mg l⁻¹)	Cl- (mg l⁻¹)	SO_4^{2-} (mg l⁻¹)	PO_4^{2-} (mg l⁻¹)
Sites											
S_1 (0-5 km)	7.02	0.243	139.7	19.6	11.4	41.3	12.9	98.4	5.4	5	0.9
S^2 (5-10 km)	7.09	0.258	142.1	19	12.1	50.9	11.5	143	3.5	4	4.8
S_3 (10-15 km)	7.13	0.324	141.5	17.8	5.6	58.2	11.6	273	1.9	3	9.5

Table 3: Spatial trends in nutrient concentrations for Dehar tributary

Parameters	pH	EC (mmhos cm⁻¹)	TDS (mg l⁻¹)	TSS (mg l⁻¹)	K (mg l⁻¹)	Ca (mg l⁻¹)	Mg (mg l⁻¹)	Na (mg l⁻¹)	Cl- (mg l⁻¹)	SO_4^{2-} (mg l⁻¹)	PO_4^{2-} (mg l⁻¹)
Sites											
S_1 (0-5 km)	7.35	0.231	153.4	18.8	7.5	56	9.4	4.3	10	3	18.1
S_2 (5-10 km)	7.19	0.402	157	17.4	33.8	57.1	10.5	44.6	5.7	5	1.2
S_3 (10-15 km)	7.14	0.577	112.8	14.4	4.3	34.2	11.7	107	8	6	0.7
S_4 (15-20 km)	7.03	0.522	158.2	16.6	12.2	40.9	12.6	223	14.5	143	17.7

within prescribed limits for irrigation. This may be due to less agricultural and residential runoff and leaching of soil contaminants. As such no trend in pH, EC and TDS was observed along a longitudinal gradient during the study. The total suspended solids increased with the increase in turbidity. TSS has shown increasing trend downstream with its highest

Table 4: Spatial trends in nutrient concentrations for Gaj tributary

Parameters	pH	EC (mmhos cm^{-1})	TDS (mg l^{-1})	TSS (mg l^{-1})	K (mg l^{-1})	Ca (mg l^{-1})	Mg (mg l^{-1})	Na (mg l^{-1})	Cl- (mg l^{-1})	SO$_4^{2-}$ (mg l^{-1})	PO$_4^{2-}$ (mg l^{-1})
Sites											
S$_1$ (0-5 km)	7.28	0.330	149.8	19.4	1.58	61.2	11.2	7.6	9.2	8	5.6
S$_2$ (5-10 km)	7.09	0.452	172.5	18.2	1.34	45.1	9.7	6.7	1.5	21	10.1
S$_3$ (10-15 km)	7.15	0.491	101.1	15.6	12.14	57.2	10.4	148.8	8.5	4	14
S$_4$ (15-20 km)	7.26	0.396	140.3	14.2	4	52.9	9.9	36.9	3.6	5	14.7

value at Site S$_1$ and lowest value at Site S$_4$ (Table 2-5).

The presence of potassium indicated that the tributaries were influenced by human activities. Its occurrence in water may be attributed to potash fertilizers and animal waste. High Ca and Mg content contributed to the total hardness of water. These occurs in water in carbonate or bicarbonates form. The tributaries remained unaffected by Mg and Ca concentration as these ranged within the limits prescribed for irrigation. Sodium presence indicated that the tributaries were influenced by human activities. Sodium found its way into tributaries from road salt, fertilizers, and human and animal waste. Chloride may have occurred in tributary due to animal waste, potash fertilizer and drainage from road-salting chemicals. Sulfate in the tributaries was primarily related to the type of minerals in the catchment and activities that burn coal, release sulfur compounds into the atmosphere which are into lake through tributaries. In particular, the increased mining activity along the length of tributaries most likely impacts on the lake, as indicated by the increased sulphate concentrations measured at Site 4 of Dehar tributary (Table 3) and Site 3 of Baner tributary (Table 5). Increased sulphate concentrations are commonly associated with mining activity as a result of the exposure of pyrite to oxygen and water (Bullock and Bell, 1997). In the present studies, highest amount of phosphates was recorded in the area where agricultural runoff and activities like bathing and washing clothes occurred in the tributary bank. Increased amount of phosphates and coliform contamination in streams closer to anthropogenic activities was also reported by Karthick and Ramachandra (2007). No spatial trend was observed along a longitudinal gradient in the nutrient concentrations of tributaries taken under study (Table 2-5).

3.2. Spatial distribution of land use catchment

The catchment of wetland under current study was spread over an area of 931.04 km 2 which was 7.41% of the total catchment of Pong reservoir. Out of 931.04 km 2, maximum area i.e. 34% was covered under forests followed by cultivated land 27%, barren land 13%, land put to non-agricultural uses 7%, culturable waste 5%, permanent pasture and other grazing lands 5%, fallow land 5% and least area under miscellaneous trees and groves 4% (Figure 1).

3.3. Status of Heavy metal in lake silt

Heavy metal viz., Fe, Cu, Cd and Zn concentration in lake silt from different stations differed significantly (Table 6). Fe in lake silt ranged from 2705.6 mg kg^{-1} to 4076.5 mg kg^{-1}
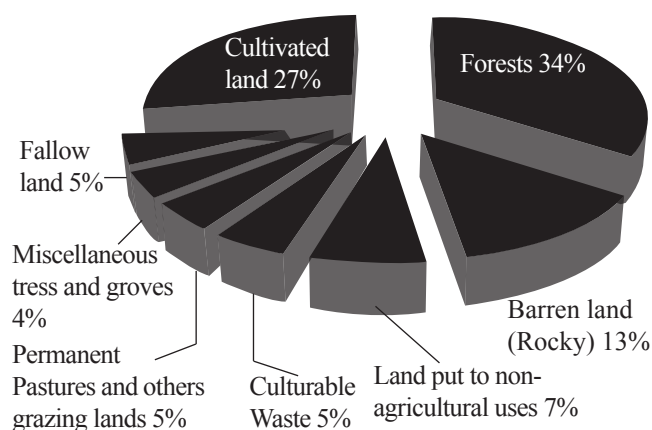

Figure 1: Spawtial distribution of land use system in the study area (%)

Table 5: Spatial trends in nutrient concentrations for Baner tributary

Parameters	pH	EC (mmhos cm^{-1})	TDS (mg l^{-1})	TSS (mg l^{-1})	K (mg l^{-1})	Ca (mg l^{-1})	Mg (mg l^{-1})	Na (mg l^{-1})	Cl- (mg l^{-1})	SO$_4^{2-}$ (mg l^{-1})	PO$_4^{2-}$ (mg l^{-1})
Sites											
S$_1$ (0-5 km)	7.45	0.174	97.4	17	1.49	43.1	9.6	9.2	5	21	19.5
S$_2$ (5-10 km)	7.56	0.269	108.6	13.2	1.03	15	9.9	14.1	11	16	15.6
S$_3$ (10-15 km)	7.11	0.107	66.7	13.8	1.58	8	10.8	10.1	18	246	10.1
S$_4$ (15-20 km)	7.3	0.349	109	12	7.7	10.2	12.4	8.5	6.05	5	18.2

Table 6: Heavy metal status in silt samples

Sampling Station	Fe (mg Kg^{-1})	Cu (mg Kg^{-1})	Cd (mg Kg^{-1})	Zn (mg Kg^{-1})
Station 1	4076.5	14.80	0.60	77.45
Station 2	2705.6	2.66	0.23	20.42
Station 3	3755	10.06	0.57	54
Mean	3512.37	9.18	0.47	50.62

with its mean value of 3512 mg kg^{-1}; Cu ranged from 2.66 mg kg^{-1} to 14.80 mg kg^{-1} with its mean value of 9.18 mg kg^{-1}; Cd ranged from 0.23 mg kg^{-1} to 0.6 mg kg^{-1} with its mean value of 0.47 mg kg^{-1} and Zn ranged from 20.42 mg kg^{-1} to 77.45 mg kg^{-1} with its mean value of 50.62 mg kg^{-1}. All soils and sediments contain some concentration (usually low) of trace and toxicmetals from natural sources. Sediments with low heavy metal concentrations are not necessarily "natural" just because the levels are indeed low. They may represent a mixture of small quantity of pollutants diluted by a large amount of natural sediment with low heavy metal content. (Herut et al., 1993). However, these background levels can vary widely depending on a number of factors such as parent material, sedimentation processes in water bodies and other things. It is usually a result of human activities that levels of metals increase and due to this pollution in soils and sediments can rise to the point where they represent a potential health or ecological risk.

4. Conclusion

No spatial trend was observed along a longitudinal gradient in the nutrient concentrations of tributaries taken under study. Heavy metal concentrations in the lake silt were within permissible limits. However, increase in their concentration in near future may cause changes in the physico-chemical composition of the water and finally become unsuitable for human consumption. So there is a need to manage the various land use activities for maintaining the quality of the wetland on sustainable basis.

5. Acknowledgement

6. References

APHA (American Public Health Association), 1998. Standard methods for the examination of water and waste water (20th Edn.). American Public Health Association, Washington, D.C., USA, 1220.

Bullock, S.E.T., Bell, F.G., 1997. Some problems associated with past mining at a mine in the Witbank coalfield, South Africa. Environmental Geology 33(1), 61-71.

George, M.G., 1962. Occurrence of permanent algal bloom in a fish tank at Delhi with special reference to factors responsible for its production. Proceedings of the Indian Academy of Sciences 56B, 354-362.

Herut, B., Hornung, H., Krom, M.D., Kress, N., Cohen, Y., 1993. Trace metals in shallow sediments from the Mediterranean coastal region of Israel. Marine Pollution Bulletin 26(12), 675-682.

Junk, W.J., 2002. Long-term environmental trends and the future of tropical wetlands. Environmental Conservation 29(4), 414-435.

Karthick, B., Ramachandra, T.V., 2007. Spatial variation of physico-chemical and hydrological parameters with land use in Venkatapur catchment, Karnataka. Asian Journal of Microbiology, Biotechnology and Environmental Sciences 9(4), 1001-1005.

Kotze, D.C., Breen, C.M., 2000. Wetland-Use: a wetland management decision support system for South African freshwater palustrine wetlands. Department of Environmental Affairs and Tourism, Pretoria, South Africa. Available from http://www.ccwr.ac.za/wetlands/.

Roggeri, H.,1995. Tropical Freshwater Wetlands: a Guide to Current Knowledge and Sustainable Management. Kluwer Acedemic Press, Dordrecht, Netherlands, 349.

Saison, C., Schwartz, C., Morel, J.L., 2004. Hyperaccumulation of metals by Thlaspi caerulescens as affected by root development and Cd-Zn/Ca-Mg interactions. International Journal of Phytology 6(1), 49-61.

Willrich, T.L., Smith, G.E., 1970. Agricultural Practice and Water Quality.Ames, Iowa State University Press, USA, 415.