Research Article

Soil quality index and nutrient in badekhola and brindaban catchments, Nepal

Abstract

Soil quality index is the indicator of soil health, physical and chemical properties. However such type of research was not done yet in catchments of Nepal. Thus this research was objectively carried out to assess the soil N, P, K and pH, soil texture and soil quality index. Badekhola and Brindaban catchments of Doti and Baitadi districts, Nepal were selected for the study site. Altogether 60 soil samples 30 from each catchment were gathered randomly from 0-10 and 10-30 cm soil pits. The collected soil samples were carried out in the lab for analysis. The result showed that silt content was the highest 66.35±1.47 at 0-10 cm in Badekhola catchment and it was the lowest 58.25±2.74 at 10-30 cm in Brindaban catchment. The highest C was nearly 191.27±9.89 t ha^{-1} at 0-10 cm in Badekhola which was the least 25.82±5.7 t ha^{-1} at 10-30 cm in Brindaban catchment. The N, P and K were the highest 92.55±12.34, 43.33±2.98 and 435.7±98.9 kg/ha at 0-10 cm depth in Badekhola catchment. The highest pH was recorded 6.11±0.17 at 0-10 cm depth in Brindaban catchment. Two tailed independent t-test showed that there were significance differences in mean value of soil C, N, P and K at 0-10 cm soil depth at 95% confidence level between two Badekhola and Brindaban catchments. The calculated soil quality index was the best in both catchments which was slightly higher 1.39 in Badekhola than 1.3 in Brindaban catchment at 0-10 cm soil depth. The research will be useful for policy maker and scientific community.

Keywords: soil quality index, nutrient status, variation of soil properties, catchments, UNFCCC

Volume 3 Issue 1 - 2018

Sharmila Nepal, Ram Asheshwar Mandal
[1]Ranger, Banke National Park, Nepal
[2]Central Department of Botany, Nepal

Correspondence: Ram Asheshwar Mandal, Central Department of Botany, Kirtipur Nepal, Tel 9841450564, Email ram.mandal@gmail.com

Received: October 26, 2017 | **Published:** February 19, 2018

Introduction

Most of the issues regarding desertification are always related to soil fertility and water quality.[1,2] Hence United Nation Framework Convention on Climate Change (UNFCCC) seriously globalized the issues of desertification in 1992. The developed and developing including hilly mountainous countries are the conference of the parties and so as Nepal.[3] The catchments in hill and Himalayan regions in the world are huge source of water.[4] The people's livelihood depends up on the regular circulation of water. Thus the soil and water health depend upon the health of Himalaya and hills in mountainous countries like India, Bhutan, Afghanistan and obviously Nepal. River, stream, canal, glaciers, river tributaries always flow from upstream to downstream.[5] The upstream and downstream are most likely related to the catchment which is defined as any area of land where precipitation collects and drains off into a common outlet. If the upstream is healthy apparently the water flowing in river, stream and river tributaries is fresh. The fresh water is base of several terrestrial, water, wetland and air ecosystem. The health of the catchment depends up on the quality of the soil it contains. In fact, several countries assess the soil quality index, physical and chemical properties of soil so that the several policy and mechanical measures can be applied to protect, improve and restore the catchment.[6,7] The management practices are applied in same way[8,9] since soil physical and chemical properties are the dominant factors to determine the soil quality. Soil quality index is an integrative indicator of environmental quality, food security and economic potentiality.[10]

Few decades, rapid depletion of natural resources is an emerging issue especially in the developing countries like Nepal. Agricultural intensification, conversion of marginal land into agriculture and intensive use of the forests have been identified as soil fertility problems in Nepal.[11] The leaching of nitrogen, run- off and erosion may increase nitrogen and phosphorus levels in surface water, which can lead to eutrophication and degradation of water quality. The dynamics of soil quality, physical and chemical properties cannot show without assessing the baseline status. Generally, the soil quality index was not considered to evaluate the quality of the catchments in Nepal. The soil quality index is the significant dimension to indicate the characteristics of the soil. It showed how the soil nutrients specifically N, P, K, pH and C were varied. Though, the vegetation is one of the best indicators of the soil nutrient and fertility, physical and chemical properties of soil and soil quality index are precise parameter to assess the quality of catchment. Such type of research was not done in Nepal. Thus this research was importantly carried out to answer the research questions like what is the status of N, P, K, pH and C, how the soil texture vary in Badekhola and Brindaban catchments and where the soil quality index is higher?

Materials and methods

Study area

Catchments lie in the south western part of Doti and Baitadi districts which are located in the far western development region of Nepal. Badekhola lies in the southern part of Doti district approximately at 29^0 17' 23.20" N and 80^0 46' 16.86" E whereas the Brindaban catchment of Baitadi district lies approximately at 29^0 33' 09.32" N and 80^0 43' 13.60" E. The elevation of Banlekh VDC of Doti district is 700 m and the elevation of Shikharpur VDC of Baitadi district is 2100 m (Figure 1). Broadly, the catchment area can be divided into forest and cultivated land. The dominant species are *Shorea robusta* (Sal), *Pinus roxburghii* (Salla), *Quercus spp* (Banjh) in the respective fields.

Soil sampling

The stratified random sampling was applied to collect the sample.

Firstly, the catchment area was divided into two strata based on catchments. Altogether 60 samples 30 from each catchment were gathered [12]. Specifically sample were taken from 0-10, 10-30 cm using the soil corer. About 500 gm of soil excavated and bagged in polythene bag, and transported to the soil lab.

$$\text{Bulk Density}\left(\text{BD g/cc}\right) = \left(\text{oven dry weight of soil}\right)/\left(\text{volume of soil in the core}\right)$$

$$\text{SOC} = \text{Organic Carbon Content \%} \times \text{Soil Bulk Density}\left(\text{Kg/cc}\right) \times \text{thickness of horizon}$$

The N was analyzed using the[14] method; soil texture and Phosphorous using[15] method, Potash using flame photometric method;[16] K and pH were analyzed using pH meter.[17]

Statistical analysis

The descriptive and inferential analysis was carried out to find the mean and compare the soil carbon, N, P, K and pH of Badekhola and Brindaban catchments. At the same time, distribution of data was evaluated using Kolmogorov-Smirnov and Shapiro-Wilk tests to examine the normality of the data. Next, the t-test was applied to compare the soil C, N, P, K and pH between Badekhola and Brindaban catchments.[12]

Soil quality index

Soil Quality Index values calculated by using the following equation[18,19]

$$\text{SOI} = \left[\left(a \times \text{RSTC}\right) + \left(b \times \text{RpH}\right) + \left(c \times \text{ROC}\right) + \left(d \times \text{RNPK}\right)\right]$$

Where,

RSTC= assigned ranking values for soil textural class RpH = assigned ranking values for soil pH ROC=assigned ranking values for soil organic carbon RN=assigned ranking values for nitrogen.

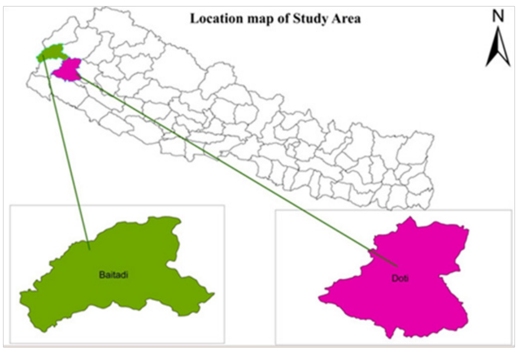

Figure 1 Map of the study area.

Lab analysis

Collected soil samples were analyzed in the lab.

Carbon content in the soil was analyzed by using dry combustion method [13].

RP=assigned ranking values phosphorus RK=assigned ranking values for potassium

And a=0.2 b=0.1 c=0.4 and d=0.3 are weighted values

corresponding to each of the parameters.

Scoring method

The scoring method developed by NARC is used to interpret SQI (Table 1).

Table 1 Commonly used soil parameters in Nepal

	Ranking values				
Parameters	0.2	0.4	O.6	0.8	1
Soil textural class	C;S	CL; SC; SiC	Si; LS	L; SiL; SL	SiCL
Soil pH	<4	4.1 -4.9	5-5.9	6-6.4	6.5-7.5
Fertility (NPK)	Low	Mod low	Moderate	Moderate High	High
SOI	Very poor	Poor	Fair	Good	Best

C, Clay; S,Sand; CL,Clay loam; SC, Sandy Clay; SiC, Silty Clay; Si,Silt; LS, Loamy sand; SiL, Silty loam; SL,Sandy loam; LS Loamy Sand; SiL,Silty loam; SL,Sandy loam; SiCL,Silty clay loam; SCL, Sandy Clay loam; SQI,Soil Quality Index.

Results and discussions

Physical properties of soil at Badekhola and Brindaban catchments, Nepal

The physical properties of soil indicated that the soil was silt in both catchments at both soil depths. In fact, the silt content was the highest 66.35±1.47 at 0-10 cm in Badekhola catchment but it was the lowest nearly 58.25±2.74 at 10-30 cm in Brindaban catchment (Table 2).

Table 2 Physical properties of soil

		Soil textures (%)			
Catchments	Soil Depth cm	Sand	Silt	Clay	Textural Class
Badekhola	0-10	26.4±2.06	66.35±1.47	8.1±0.95	SILT
Brindaban		28.2±5.46	62.6±4.4	9.2±1.6	SILT
Badekhola		31.64±4.55	61.47±3.99	6.9±1.29	SILT
Brindaban	30-Oct	37.5±3.24	58.25±2.74	3.55±0.79	SILT

Chemical properties of soil in Badekhola and Brindaban catchments, Nepal

The result showed the chemical properties were differed in the catchments. The C was the highest about 191.27±9.89 t ha^{-1} at 0-10 cm in Badekhola but it was the least 25.82±5.7 t ha^{-1} at 10- 30 cm in Brindaban catchment (Table 3). About similar trend was found in case of N, P, K and pH in the catchments.

Table 3 Chemical properties of soil

Soil depth	Catchment	pH Value	C t ha-1	N(kg/ha)	P(kg/ha)	K(kg/ha)
0-10	Badekhola	5.73±0.17	191.27±9.89	92.55±12.34	43.33±2.98	435.7±98.9
	Brindaban	6.11±0.17	121.62±11.93	81.34±9.12	10.67±2.49	370.24±81.35
	Badekhola	5.95±0.16	77.21±6.21	37.8±6.17	16.4±2.28	268.97±79.19
30-Oct	Brindaban	5.98±0.14	25.82±5.7	31±4.44	8.39±2.12	310.9±82.14

Citation: Nepal S, Mandal RA. Soil quality index and nutrient in badekhola and brindaban catchments, Nepal. *MOJ Eco Environ Sci.* 2018;3(1):43–46.
DOI: 10.15406/mojes.2018.03.00066

Statistical comparison of differences in chemical soil properties

Two tailed independent t-test showed that there were significance differences in mean value of soil C, N, P and K at 0-10 cm soil depth at 95% confidence level between two Badekhola and Brindaban Catchments. However, there were no significance differences in pH values in these catchments and it was also insignificant differences in P and K at 10-30 cm soil depth at 95% confidence level (Table 4).

Table 4 Statistical comparison

	Two tailed T-test (P-Value)				
Soil Depth cm	pH	C	N	P	K
0-10	0.23	0.02	0.03	0.01	0
30-Oct	0.31	0	0.02	0.07	0.06

Soil quality index at badekhola and brindaban catchments, Nepal

The estimated soil quality index showed that the soil quality was the best in both catchments. Specifically, the estimated soil quality index was slightly higher 1.39 in Badekhola than nearly 1.3 in Brindaban catchment at 0-10 cm soil depth. The soil quality index was lower at 10-30 cm depth (Table 5).

Table 5 Soil quality index of different land use in its depth at different catchment

Catchments	Soil depth cm	Soil quality index	Quality of catchment
Badekhola	0-10	1.39	Best
Brindaban		1.3	Best
Badekhola		1.06	Best
Brindaban	30-Oct	1.03	Best

Discussion

The physical properties, chemical properties and soil quality index are the indicator of soil quality in the catchment. The high values of these properties and soil quality index indicated that the soil were silt in both catchments at both soil depths. The soil C, N, P, K and soil quality index were decreased according to increase in soil depth,[20,21] same pattern was recorded in our study. The soil quality depends upon various biotic and abiotic factors such as micro-climate, faunal diversity, land use, and management.[22] The soil quality index was higher at 0-10 cm soil depth in both catchments. The higher value was observed in Badekhola than Brindaban catchment. The forest vegetation is working as the indicator of soil fertility[23] which was observed better in Badekhola catchment. Thus the C, N, P, K and soil quality index were higher in Badekhola catchment. The soil texture was quite similar in both catchments.

The mean carbon of soil was the highest nearly 23.62 t ha^{-1} at root zone of *Emblica officinalis* stratum[24] this was about to similar with our research, the C value at 10-30 cm soil depths of Brindaban catchment. N in Bisbitty public plantation in Mahottary Nepal was nearly 42.00 Kg/ha in 0-0.1m depth[25] which was close to the N value (37.8±6.17) at 10-30 cm soil depth of Badekhola. The soil having very less N % is considered as the very low fertile soil.[26] In fact, the silt content was the highest 66.35±1.47 at 0-10 cm in Badekhola catchment but it was the lowest nearly 58.25±2.74 at 10-30 cm in Brindaban catchment. The soil texture at the bank of the river and ocean is dominated by sandy soil but it is silt or loamy texture in the forest.[27] Similar research carried out in forest in Dailekh district Nepal showed that soil was silt[28] which is supportive finding to our research.

The study done by[29] showed that the N, P and K were 453.24, 25.46 and 340.62 kg/ha respectively in plantation of *Leucaena leucocephala*. In addition,[30] showed that the values of N, P and K were 843, 61 and 310 kg/ha in mixed Schima- Castonopsis forest of Gaukhureshwar Community Forest, Nepal. On the other hand,[31] reported that phosphorus and potassium in the soil of the pure *Shorea robusta* forest were 76.64 and 267.73 kg/ha respectively. Some of these values are similar and some of them are contradicted with the values of our research.

Conclusion

The physical, chemical properties and soil quality index were differed in Badekhola and Brindaban catchments. Soil chemical properties like pH, C, N, K and P were significantly varied in the catchments at 0-10 and 10-30 cm soil depths. The values of physical and chemical properties of soil were higher in Badekhola than Brindaban catchments. Moreover, the soil quality was the best in both catchments. Further studies are required to explore the soil quality of the catchment so that policy can be made accordingly to manage it.

Acknowledgements

Special gratitude goes to International water management Institute (IWMI) for granting me financial support to conduct this research in Badekhola catchment, Doti and Brindaban catchment, Baitadi. I appreciate Ram Singh Thapa, project director, BCRWME for his valuable suggestions during data analysis and for providing guidance during field work. I am thankful to Amar Adhikari, Soil conservation officer BCRWME Dadeldhura for his suggestions during data analysis and report writing.

Conflicts of interest

The authors are agreed to publish the paper through MOJ Ecology and Environmental Science. This paper is not submitted anywhere else and not published in any journal. There is no conflict of interest.

Funding

None.

References

1. IPCC. Fourth Assessment Report. Intergovernmental Panel on Climate Change Secretariat. Switzerland; 2007. p. 45–51.
2. UNGA. Climate Change and the Most Vulnerable Countries: The Imperative to Act. United Nations General Assembly. 2008;32–34.
3. Agrawala S, Raksakulthai V, Van Aalst M, et al. Development And Climate Change In Nepal:Focus On Water Resources And Hydropower. Organisation for Economic Co– operation and Development. 2003. p. 23–24.
4. Makaudze E. The Impact of Climate Change, Desertification and Land Degradation on the Development Prospects of Landlocked Developing Countries United Nations Office of the High Representative for the Least Developed. Landlocked Developing Countries and Small Island Developing States (UN–OHRLLS), 2013. p. 44– 47.
5. Singh SP, Bassignana–Khadka I, Karky BS, et al. Climate Change in the Hindu Kush–Himalayas The State of Current Knowledge, International Centre for Integrated Mountain Development. Nepal, India; 2011. p. 14–16.
6. Kosmas C, Gerontidis S and Marathianou M. The effect of land use change on soils and vegetation over various lithological formations on Lesvos (Greece). Caten. 2000a;40 (1):51–68.

7. Fernandes JC, Gamero CA, Rodrigues JGL, et al. Determination of the quality index of a Paleudult under sunflower culture and different management systems. Soil and Tillage Research. 2011;112(2):167–174.

8. Karlen DL, Mausbach MJ, Doran JW, et al. Soil quality: a concept, definition, and framework for evaluation. *Soil Sci Soc Am J*. 1997;61(1):1–4.

9. Young ZH, Singh BR, Sitaula BR. Soil organic carbon fractions under different land uses in Mardi watershed of Nepal. Communications in soil science and plant analysis. 2004;35(1):615–629.

10. Warkentin BP, Fletcher HF. Soil quality for intensive agriculture. Intensive Agriculture Society of Science, Soil and Manure. Proceedings of the International Seminar on Soil Environment and Fertilizer Management. *National Institute of Agricultural Science*. 1997;594–598.

11. Schreiber H, Shah PB, Lavkulich LM. Soil Acidification and its Impact on Nutrients Deficiency; With Emphasis on Red Soils and Pine Litter. *Additions in Soil Fertility and Erosion Issues in the Middle Mountains of Nepal*. 1995;37–39.

12. Kothari CR. Research Methodoloy, Methods and Techniques, New Age International Publication Limited. 2004.

13. Walkley AE and Black JA. An Examination of the Method for Determining Soil Organic Method, and Proposed Modification of the Chromic Acid Titration Method, Soil Science. 1958;37(1):29–38.

14. Kjeldahl J. Neue Methode zur Bestimmung des Stickstoffs in organischen Körpern. *Zeitschrift für analytische Chemie*. 1883;22(1):366– 383.

15. Olsen SR, Sommers LE. Phosphorus. In:Page AL, editor. Methods of Soil Analysis.Part 2, 2nd ed.. Chemical and Microbiological Properties, ASA–SSSa. 1982;54–55.

16. Murphey J, Riley JP. A modified single solution method for estimation of phosphate in natural matters. *Anal Chim Acta*. 1965;27(1):3–36.

17. Anderson JM, Ingram JSI. Total Organic carbon in soil:colorimetric method. Tropical soil biology and fertility:A handbook of methods. 2nd ed. Wallingford:CAB International. 1993;62–64.

18. Amacher MC, Perry CH. Soil vital signs: A new Soil Quality Index (SQI) for assessing forest soil health. 2007;21–22.

19. Karlen DL, Stott DE. A framework for evaluating physical and chemical indicators of soil quality. In:Doran JW & Coleman DC (Eds.), Defining soil quality for a sustainable environment. Madison. WI: Soil Science Society of America. 1994;53–72.

20. Liebig MA, Varvel G, Doran J. A simple performance–based index for assessing multiple agroecosystem functions. *Agronomy Journal*. 2001;93(1):313–318.

21. Vejre H, Callesen I, Vesterdal L, et al. Soil Science Society. *America Journal.* 2003;67(1):335–343.

22. Shrestha BM, Singh BR. Soil and vegetation carbon pools in a mountainous watershed of Nepal. Nutrient Cycle Agro–ecosystem 2008;81(2):179–191.

23. Andrews S, Karlen D, Mitchell J. A comparison of soil quality indexing methods for vegetable production systems in Northern California. Agriculture. *Ecosystems and Environment*. 2002;90(1):25–45.

24. Mandal R A, Dutta IC, Jha PK. Soil carbon, nitrogen and texture dynamics at root zone and between plants in Riverine Plantation of Acacia catechu, Dalbergia sissoo. *Pyllanthus emblica and Eucalyptus camaldulensi*. 2017;7(2):1–11.

25. Mandal RA, Dutta IC, Jha PK, et al. Potential Carbon Offset in Public Plantation, Tarai, Nepal:Offering Opportunity for REDD+ and Soil Fertility. *International Journal of Ecology and Development*. 2013;25(2):1–11.

26. Dawud SM, Vesterdal L, Raulund–Rasmussen K. Mixed–species effects on soil C and N stocks, C/N ratio and pH using a transboundary approachin adjacent common garden douglas–fir and beech stands. *Forests*. 2017;8(4):95–98.

27. Matsui N, Meepol W, Chukwamdee JC . Soil Organic Carbon in Mangrove Ecosystems with Different Vegetation and Sedimentological Conditions. *Journal of Marine Science and Engineering*. 2015;3(1):1404–1424.

28. Bajracharya RM, Sharma S, Sitaula B. Soil quality in the Nepalese context – Ananalytical review. *International Journal of Ecology and Environmental Sciences*. 2007;33(3):143–158.

29. Yadav JN, Manjan SK. Use of Biological Resources for Reclamation of River Damaged Land, Proceedings of National Seminar on Sustainable. Use of Biological Resources in Nepal. 2007;112– 115.

30. Baral SK. Impacts of Forest Management on Selected Ecosystem Properties (A Case Study from a Community Forst and A Municipality Owned Forest in Midhills of Central Nepal, Thesis submitted in partial fulfillment of the requirement for the degree of MSc European Forestry. University of Natural Resources and Applied Life Sciences (BOKU) Vienna; 2008. p. 66–68.

31. Paudel S, Shah JP. Physiochemical characteristics of soil in tropical Sal (*Shorea robusta*) forests in eastern Nepal. *Himalayan Journal of Science*. 2003;1(2):107–110.

Citation: Nepal S, Mandal RA. Soil quality index and nutrient in badekhola and brindaban catchments, Nepal. *MOJ Eco Environ Sci.* 2018;3(1):43–46.
DOI: 10.15406/mojes.2018.03.00066