ISSN:2319-2607 IISUniv.J.Sc.Tech. Vol.9(1), 38-47 (2020)
RESEARCH ARTICLE

Physico-chemical Analysis of Soil from Restored and Unrestored Areas of Barodiya Village, Chaksu

Himanshi Shukla*, Sonal Jain, Shelja K Juneja
Department of Environmental Science, IIS (deemed to be University), Jaipur

Abstract

The worlds ecosystems and their biodiversity have been significantly degraded, which has a negative impact on human livelihoods. Therefore, timely and effective interventions for ecological restoration should change this degradation process because it is essential to maintain the health of the ecosystem. Such practice of Ecological Restoration has been observed in Chaksu Block, Jaipur, Rajasthan, which was hit by floods in 1981, resulting in massive soil erosion, leaving the land infertile and unproductive, and later restored by the forest department with the help of local population. In the present study, we aimed to analyse the various physico-chemical parameter of soil with their comparison between the restored and unrestored areas of Barodiya village of Chaksu Block, Jaipur. The results of the present study give us an idea of the improved fertility of the soil in the reclaimed area, which demonstrates that the reconstruction measures adopted by the community and the government are peaceful and effective.

Keywords: Ecological Restoration, Land Degradation, Physico-chemical Parameters, Soil erosion, Soil quality

Introduction

Anthropogenic activities lead to significant disturbance in our natural environment, which results in Environmental Degradation (Redman, 1999). Environmental degradation, specifically degradation of land and soil is one of the biggest concerns that mankind is facing today. Through its impact on agricultural environment and its productivity, soil degradation leads to social and political instability, intensive use of marginal and fragile lands, enhanced rate of deforestation, soil erosion and accelerated runoffs, emission of greenhouse gases into the atmosphere and pollution of natural waters. (Johnson *et al.*, 1997). In this way ecological restoration is becoming an important character of ecosystem management. The Society for Ecological Restoration (SER) stated that ecological restoration is intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability (SER, 2004).

Thus, Ecological Restoration has been found efficient and effective in treating a degraded land. Restoration of a degraded land include the process of rehabilitation of a site that has been destroyed once by natural or anthropogenic activity (Dobson *et al.*, 1997). Several restoration practices are going throughout the world. One example is the land of Chaksu block of Jaipur district, Rajasthan, which has been restored after degradation caused by heavy rainstorm in 1981.According to the press reports, 80 villages of Chaksu block were affected (Thooni Ram Laxman Pura, Barodiya, Nadi-ghati, Chandel Kalan, Kanwarpura Laxmi Pura, Roopwas, etc).

To restore the degraded land, Gram Panchayat of Chaksu block had started plantation programme at 140 sites. The flood affected sites were planted with various tree species that are common in targeted ecosystem (Dhar *et al.*, 1982). Barodiya village of Chaksu block was selected for the present study in which soil properties of restored area along with unrestored area were analysed.

Objectives

- To analyse the physico-chemical properties of soil from unrestored site of Barodiya village.
- To analyse the physico-chemical properties of soil from restored site of Barodiya village.
- To compare the soil quality of restored and unrestored sites of Barodiya village.

Significance

This research work shows the significance of ecological restoration on a degraded land. The comparative study of restored and unrestored land with respect to their physio-chemical properties helps in understanding the improvement in the soil quality which further leads to better agricultural practices, better health, socio-economic development and better environment for the local community.

*Corresponding Author Email: shuklahimanshi016@gmail.com

Materials and Methods

Collection of Soil Samples

Soil samples were collected from restored and unrestored areas of Barodiya village, at depth of 10 cm, in pre-sterilized polypropylene zip lock bags. Each sample was collected 1 kg from both the lands (5 restored and 5 unrestored). Restored samples were marked as R1, R2, R3, R4, R5 and unrestored samples were labelled as UR1, UR2, UR3, UR4, UR5. Soil samples were collected twice [once in the month of October (2019) and once in the month of January (2020)]. The soil samples were stored at 4°C for physico-chemical characterization. Samples were compared through physico-chemical parameters, to analyse how the flood altered the Soil quality and nutrient efficiency.

Physico-chemical Characterisation of Soil

The physico-chemical characteristics of the soil samples were analysed from Restored and Unrestored areas of Barodiya village by using following methods; Water holding capacity (Filtration method), Moisture Content (oven method), Soil texture (Gee and Bauder, 1986), pH and Electrical Conductivity (Jackson 1973), Organic Carbon and organic matter (Walkley black method, 1934), Available Phosphorous (Olsens method, 1954), Exchangeable Calcium and Magnesium (EDTA Titrimetric Method), Available Potassium (Flame photometric method), Total Nitrogen (Maiti, 2003).

Statistical Analysis

All the samples were analysed in triplicates. All the observations from the experimental results were expressed in terms of mean ± standard error. The results were compared using the students t-test (two tailed paired t-test) and significance level were considered at $p<0.05$. The statistical analysis was performed using SPSS software [IBM SPSS Statistics version 22.0]

Results and Discussions

Results from physico-chemical analysis from restored and unrestored soil samples are shown in table 1 and 2;

Table 1. Physico-chemical characterisation of soil samples taken in October

MONTH→	**OCTOBER**									
SAMPLES→	**RESTORED**					**UNRESTORED**				
PARAMETERS ↓	**R1**	**R2**	**R3**	**R4**	**R5**	**UR1**	**UR2**	**UR3**	**UR4**	**UR5**
Water holding capacity%	46.56%	42.70%	44.03%	42.00%	40.07%	42.58%	45.33%	42.81%	40.45%	40.05%
Moisture content%	4.53%	4.83%	3.24%	17.49%	2.97%	4.34%	1.55%	3.91%	2.34%	3.99%
Texture	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy
pH	8.30±0.00	8.23±0.033	8.33±0.033	8.13±0.033	8.10±0.00	8.43±0.120	8.36±0.384	8.33±0.133	8.23±0.066	8.50±0.057
Electrical conductivity (MS)	0.25±0.019	0.23±0.160	0.24±0.023	0.26±0.006	0.21±0.007	0.40±0.056	0.29±0.005	0.27±0.027	0.35±0.007	0.39±0.020
Organic carbon%	0.57±0.015	0.54±0.027	0.24±0.018	0.27±0.00	0.22±0.009	0.16±0.015	0.11±0.009	0.11±0.018	0.24±0.027	0.15±0.018
Organic matter%	0.98±0.027	0.94±0.047	0.43±0.031	0.47±0.00	0.39±0.015	0.28±0.027	0.20±0.015	0.29±0.031	0.42±0.047	0.26±0.031
Available calcium(ppm)	0.84±0.023	0.62±0.013	0.44±0.046	0.50±0.013	0.48±0.046	0.64±0.040	0.53±0.066	0.46±0.066	0.46±0.070	0.37±0.013
Available magnesium(ppm)	0.14±0.48	0.17±0.028	0.30±0.029	0.25±0.029	0.31±0.024	0.12±0.037	0.29±0.035	0.20±0.029	0.21±0.028	0.29±0.014
Available potassium(mg/gm)	1.18±0.014	1.65±0.011	1.08±0.024	1.17±0.010	1.46±0.021	0.76±0.018	0.54±0.016	0.83±0.024	0.67±0.008	0.90±0.017
Available phosphorous(kg/ha)	4.68±0.130	4.21±0.103	0.41±0.029	4.06±0.107	0.35±0.089	2.21±0.233	1.97±0.136	1.37±0.079	2.03±0.029	0.25±0.005
Total nitrogen%	0.39±0.005	0.40±0.00	0.40±0.007	0.39±0.010	0.34±0.004	0.31±0.004	0.34±0.00	0.31±0.005	0.32±0.006	0.31±0.025

Each value of chemical parameters represents mean of three triplicates.
Each value represent mean ± standard error (S.E.)
Significance level: $p<0.05$
Statistical comparison: Restored v/s Unrestored

Table 2. Physico-chemical characterisation of soil samples taken in January

MONTH→	JANUARY									
SAMPLES→	RESTORED					UNRESTORED				
PARAMETERS ↓	R1	R2	R3	R4	R5	UR1	UR2	UR3	UR4	UR5
Water holding capacity%	68.87%	86.90%	73.61%	72.09%	103.92%	54.94%	76.85%	39.19%	48.52%	53.13%
Moisture content%	6.76%	10.05%	7.58%	8.08%	9.36%	0.78%	3.00%	1.25%	2.52%	3.80%
Texture	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy
pH	10.0±0.05	9.96±0.03	9.86±0.03	9.86±0.03	9.83±0.03	10.43±0.08	10.20±0.000	10.16±0.033	10.20±0.05	10.10±0.05
Electrical conductivity (MS)	0.35±0.002	0.37±0.002	0.35±0.005	0.35±0.004	0.35±0.004	0.48±0.002	0.37±0.002	0.80±0.005	0.48±0.002	0.37±0.003
Organic carbon%	1.07±0.007	0.93±0.011	0.81±0.074	0.63±0.007	0.80±0.019	0.42±0.019	0.44±0.025	0.57±0.046	0.23±0.019	0.32±0.032
Organic matter%	1.85±0.012	1.60±0.022	1.40±0.127	1.09±0.012	1.39±0.033	0.74±0.033	0.76±0.044	0.99±0.079	0.40±0.033	0.56±0.055
Available calcium(ppm)	0.52±0.04	0.69±0.013	0.53±0.035	0.65±0.013	0.56±0.023	0.34±0.013	0.52±0.040	0.50±0.013	0.53±0.013	0.53±0.026
Available magnesium(ppm)	0.38±0.037	0.40±0.021	0.28±0.032	0.26±0.014	0.29±0.032	0.29±0.016	0.26±0.028	0.27±0.008	0.25±0.008	0.30±0.029
Available potassium(mg/gm)	1.79±0.102	2.09±0.136	1.37±0.196	1.05±0.147	1.72±0.212	1.07±0.067	0.60±0.127	0.87±0.127	0.93±0.256	0.56±0.127
Available phosphorous(kg/ha)	6.36±0.051	6.89±0.136	4.71±0.107	5.91±0.051	1.19±0.298	4.53±0.507	5.49±0.079	4.03±0.103	3.49±0.051	2.24±0.103
Total nitrogen%	0.21±0.000	0.19±0.002	0.20±0.002	0.20±0.001	0.19±0.004	0.16±0.000	0.17±0.003	0.17±0.001	0.16±0.002	0.17±0.001

Each value of chemical parameters represents mean of three triplicates.
Each value represent mean ± standard error (S.E.)
Significance level: $p<0.05$
Statistical comparison: Restored v/s Unrestored

Water Holding Capacity

Water holding capacity of soil refers to the amount of maximum water, which can be held by the saturated soil. It is associated to the size distribution and number of soils pores (Miller and Turk, 2002). The results of our study showed that there was no significant difference ($p>0.05$) in the month of October whereas, the values of restored soil samples were significantly higher ($p<0.05$) as compared to unrestored soil samples in the month of January (Fig. 1). In the present study the values of water holding capacity of our restored and unrestored soil samples were in the same range with the values reported by Deb *et al.* (2014). Results of our study were also more or less similar to Bordoloi *et al.* (2019), which supports the increase in the water holding capacity of restored soil from the month of October to January may be attributed to an increase amount of organic matter of that land.

Moisture Content

Moisture content of the soil is the most important and useful factor which is affected by the pH, aeration and availability of nutrients to plants (Miller and Turk, 2002). Result of our study showed that no significant difference ($p>0.05$) was found between the samples of restored and unrestored soil in both the months (Fig. 2). According to Addis and Abebaw (2015) soil moisture content is directly proportional to its water holding capacity. Results of their study were found to be in the same range of ours. Another similar range of results were found to be accomplished by Ganorkar and Chinchmalatpure (2013).

Soil Texture

Soil texture is one of the important determinants of soil related to its many physical, chemical and hydrological factors (Adhikari and Adhikari, 2007). The particle size distribution of soil samples was found to have the mean value of (%) 94.01, 4.79, 0.18 for sand, silt and clay respectively (Table 3). Thus, the fraction of sand was highest followed by silt and clay according to the Soil textural triangle based on the U.S. particle size (Maiti, 2003). This was found to be similar with some other studies Igwe and stahr, 2004; Ano *et al.* (2007); Onweremadu *et al.* (2007) and it is the characteristic of soil of Barodiya village of Chaksu Block

pH and Electrical Conductivity (EC)

The amount of pH reflects the soil acidity and alkalinity. pH and Electrical conductivity (EC) of soil is a measurement that correlates with various other soil properties that affects its soil texture, cation exchange capacity, organic matter, drainage conditions, salinity and subsoil characteristics (Rai *et al.*, 2011). Results of our study showed that the pH (Fig. 3) and EC (Fig. 4) of all the restored and unrestored soil samples in both the months were found to be moderately alkaline to very strongly alkaline and low to medium respectively, according to the ratings given by Bruce and Rayment, (1982). Results of the current pH range is similar with the values reported by Solanki and Chavda (2012) in the forest of Victoria park reserve, Bhavnagar Gujarat. Results of the current electrical conductivity range were found to be similar in the range reported by Solanki and Chavda (2012). Akpoveta *et al.* (2014) also reported high value of electrical conductivity in farmlands of Onitsha and Asaba states of Nigeria, which were affected by flood as compared to the control site. The high electrical conductivity and pH also make soil unsuitable for plant growth, thus, the decrease in these parameters ultimately increases the fertility of soil.

Organic Carbon (OC) and Organic Matter (OM)

Soil organic carbon (OC) and organic matter (OM) is one of the major chemical parameters of soil quality because it directly affects soil physical structure, penetration of roots and water movement (Sarwar *et al.*, 2010). Results of organic carbon (Fig. 5) and organic matter (Fig. 6) in our study were found to be significantly higher ($p<0.05$) in the samples of restored soil than the samples of unrestored soil in both the months. In the present study improved conditions of soil organic matter and carbon supports the green cover in the restored area. The results of the present study can be corroborated by the results of Wagh *et al.* (2013). The results of the present study are also supported by Ogbodo (2011). In our study lower value of organic matter in unrestored soil may be due to the removal and washing away of nutrients by surface runoff i.e., by erosion.

Total Nitrogen

Nitrogen remains in the soil system in many forms and transforms very easily from one form to another (Solanki and Chavda 2012). Nitrogen is the most important element used in fertilizers to which plants react very quickly. In

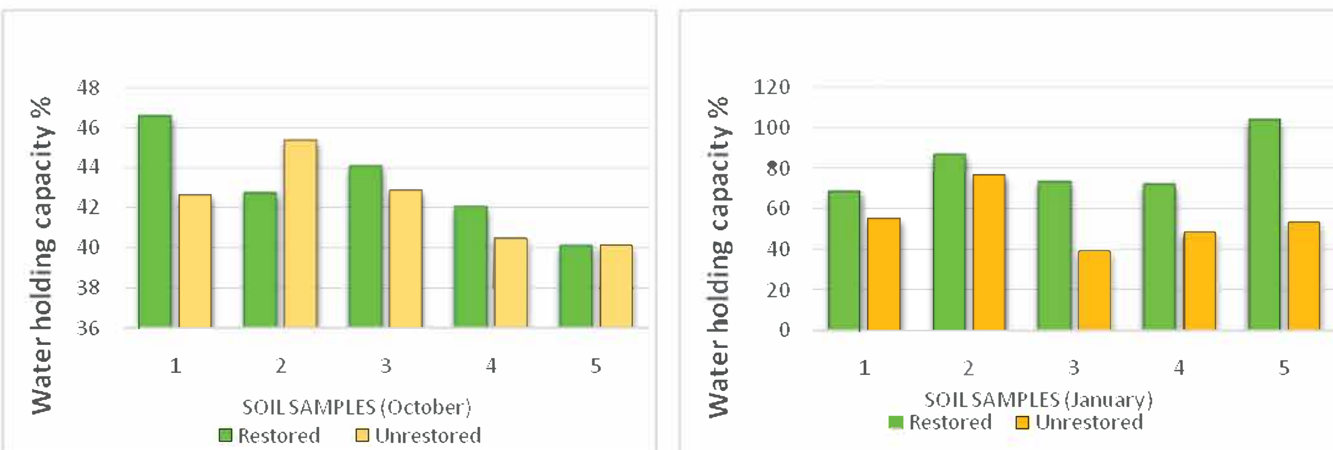

Fig. 1. Water Holding Capacity of Restored and Unrestored Soil Samples

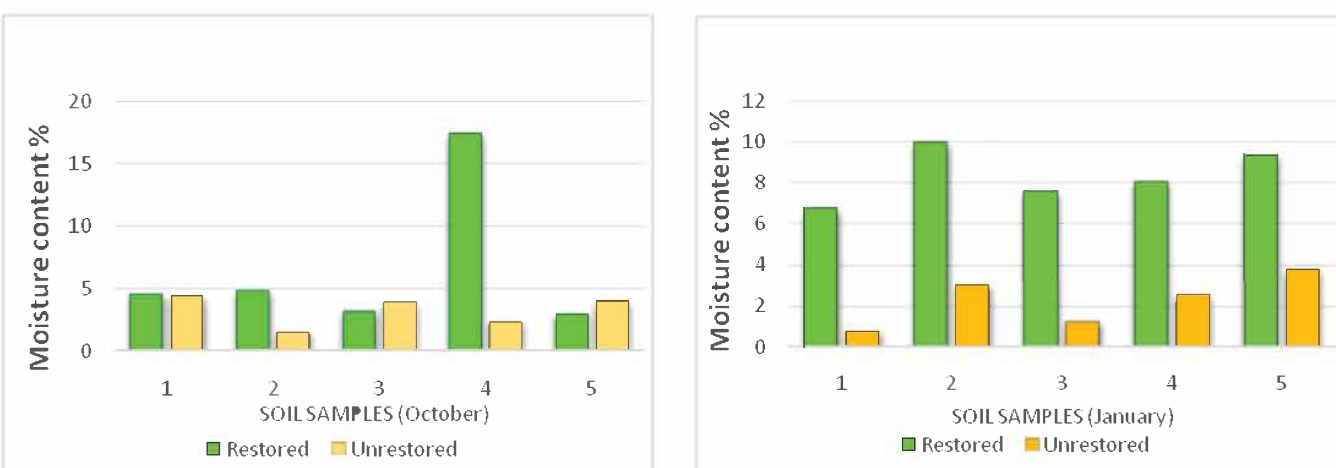

Fig. 2. Moisture Content of Restored and Unrestored Soil Samples

the present study that value of nitrogen was found to be significantly higher ($p<0.05$) in the restored soil samples than in the unrestored ones (Fig. 7). According to Maharana and Patel (2013), improvement in the amount of total nitrogen in the soil was reported in various recovering mine overburden spoil over the time. Results of our study were found in the similar range of the results obtained by Saravanakumar *et al.* (2008). The higher values of total nitrogen in the restored soil samples in our study may be due to an increase in the water content of soil due to rainfall and also the beneficial environment which favours the growth of nitrogen fixing bacteria in the soil.

Table 3. Soil Texture Analysis

Month	October			
Soil Samples	**Sandy**	**Silt**	**Clay**	**Textural Class**
R1	94.30	5.69	0.01	Sandy
R2	94.10	5.84	0.06	Sandy
R3	93.90	5.96	0.14	Sandy
R4	94.30	5.61	0.09	Sandy
R5	93.80	6.09	0.11	Sandy
UR1	93.40	6.36	0.24	Sandy
UR2	94.40	5.31	0.29	Sandy
UR3	95.90	3.79	0.31	Sandy
UR4	94.90	4.84	0.26	Sandy
UR5	93.70	6.03	0.27	Sandy
Month	**January**			
Soil Samples	**Sandy**	**Silt**	**Clay**	**Textural Class**
R1	95.18	4.80	0.02	Sandy
R2	95.74	4.15	0.11	Sandy
R3	96.13	3.86	0.01	Sandy
R4	95.99	3.88	0.13	Sandy
R5	94.86	4.96	0.18	Sandy
UR1	95.55	4.04	0.41	Sandy
UR2	96.32	3.31	0.37	Sandy
UR3	96.14	3.51	0.35	Sandy
UR4	95.89	3.88	0.23	Sandy
UR5	95.77	4.04	0.19	Sandy

Available Phosphorous

Phosphorous (P) is a vital element, also classified as a macronutrient because of the relatively large amounts of P required by plants. Phosphorous is one of the major substances which is generally added in fertilizers (Solanki and Chavda, 2012). Results of our study showed that there was no significance difference ($p>0.05$) between the samples of restored and unrestored soil in both the months (Fig. 8). According to Dilip *et al.* (2013) higher values of phosphorous were found in the month of January in eastern Himalayas which is quite similar to our results. Adeleye *et al.* (2010) also found the range of available phosphorous similar to our study. The low values of phosphorous in our results could be due to the removal of top layer of sediments by heavy rainfall and flood.

Exchangeable Calcium and Magnesium

Calcium and Magnesium are the most plentiful minerals found in soil. These are also known as secondary nutrients. These nutrients improve the structure of soil by increasing the penetration of water and prepare a more favourable environment for growth of plant and another microorganism (Haby *et al.*, 1990). Exchangeable calcium was found to be significantly higher ($p<0.05$) in the restored soil samples (Fig. 9) whereas in magnesium, no

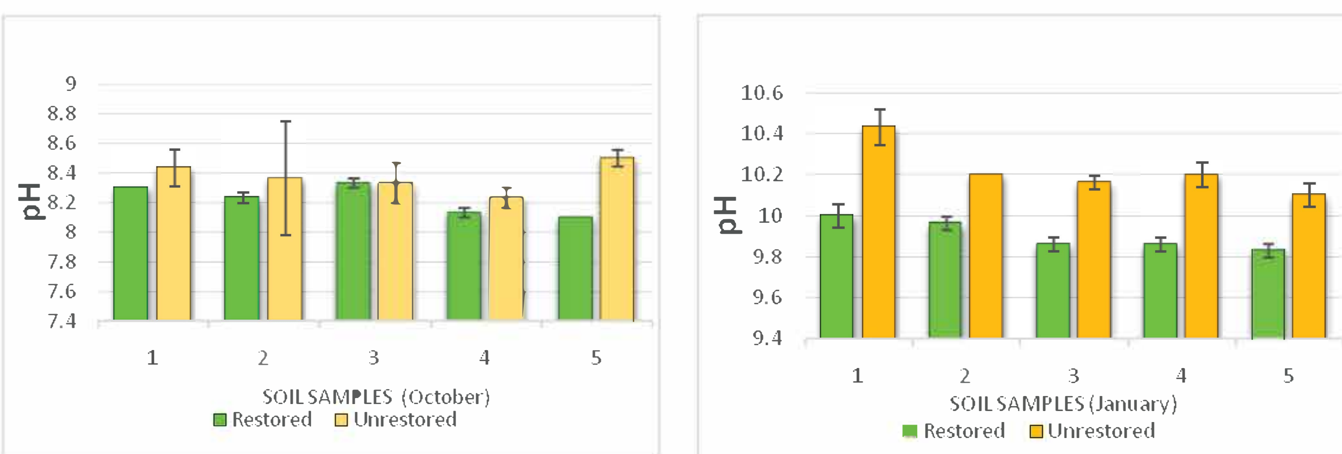

Fig. 3. pH of Restored and Unrestored Soil Samples

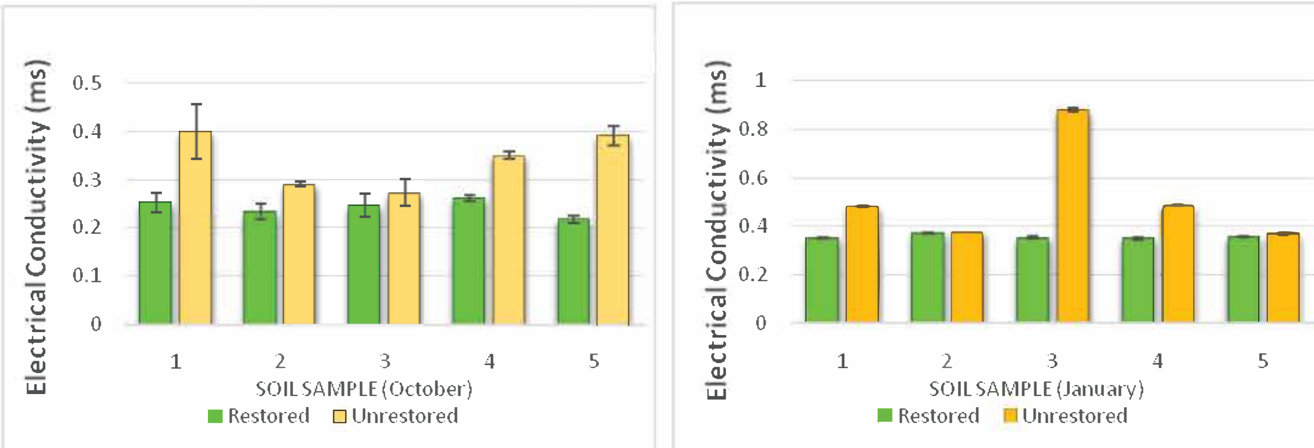

Fig. 4. Electrical Conductivity of Restored and Unrestored Soil Samples

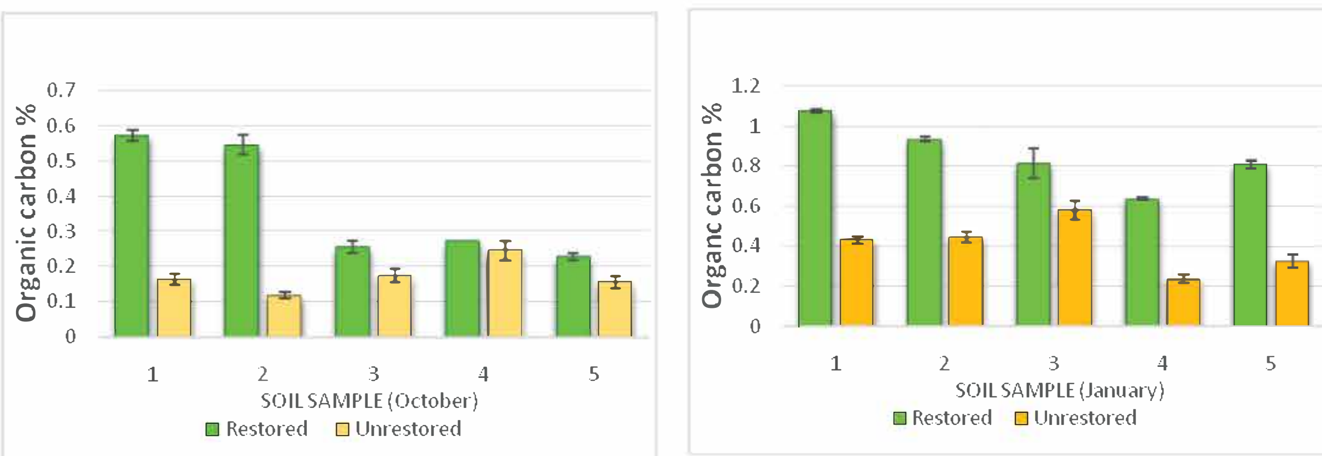

Fig. 5. Organic Carbon of Restored and Unrestored Soil Samples

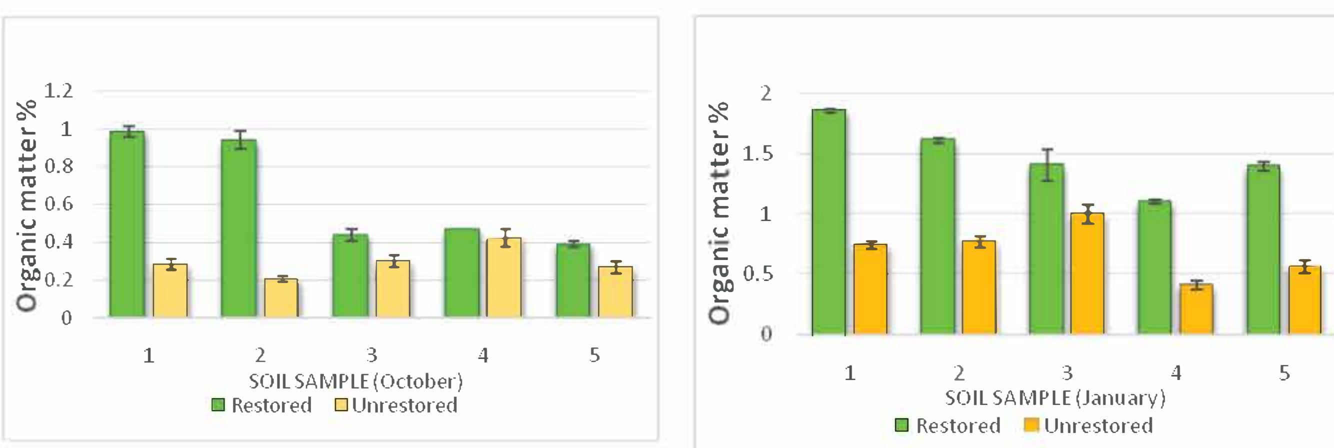

Fig. 6. Organic Matter of Restored and Unrestored Soil Samples

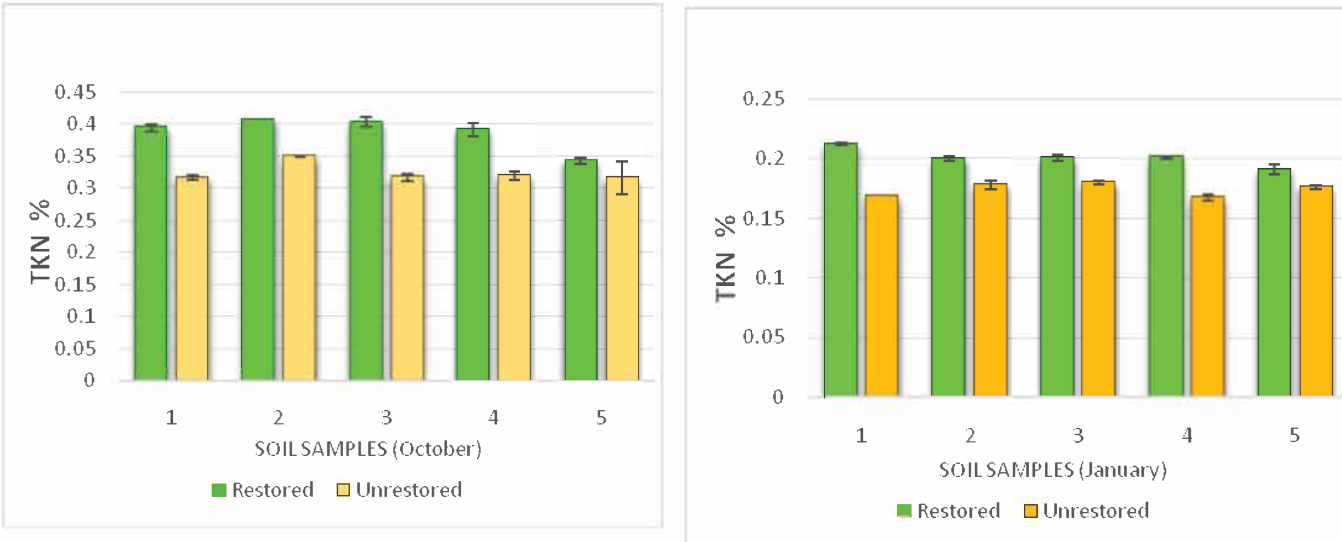

Fig. 7. Total Kjeldahl Nitrogen of Restored and Unrestored Soil Samples

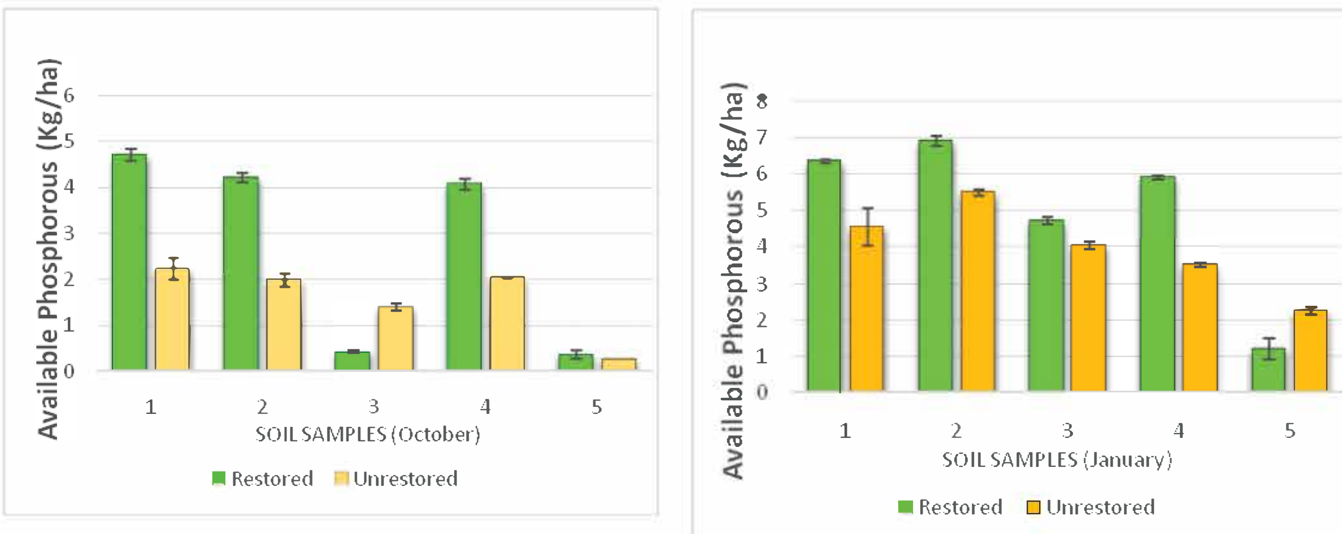

Fig. 8. Available Phosphorous of Restored and Unrestored Soil Samples

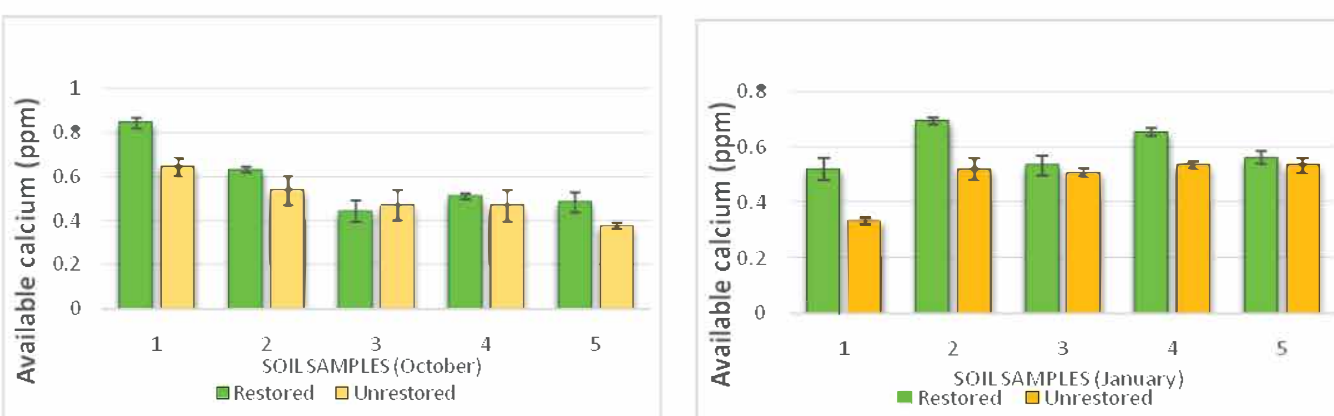

Fig. 9. Available Calcium of Restored and Unrestored Soil Samples

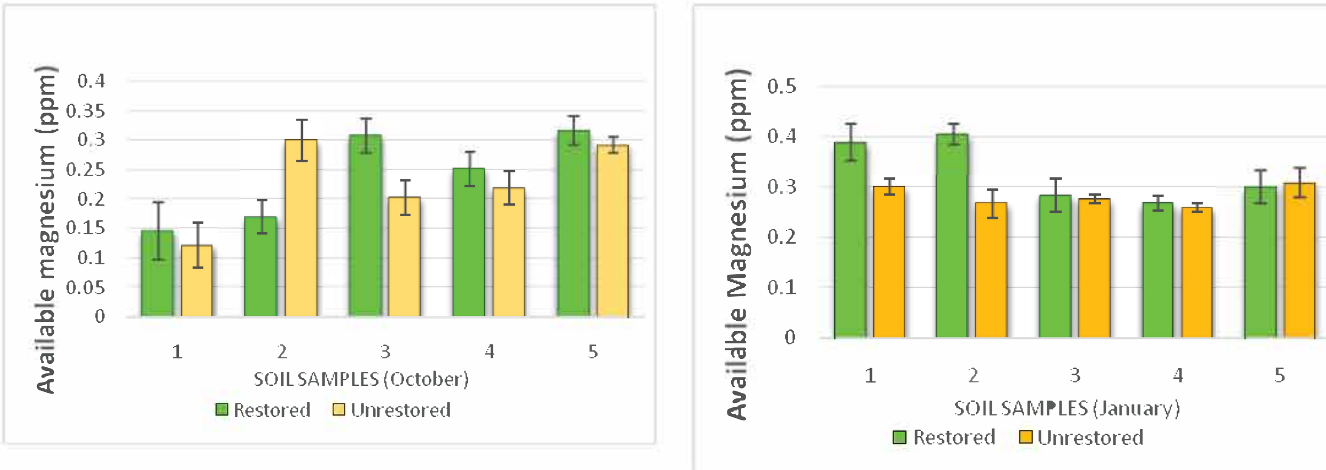

Fig. 10. Available Magnesium of Restored and Unrestored Soil Samples

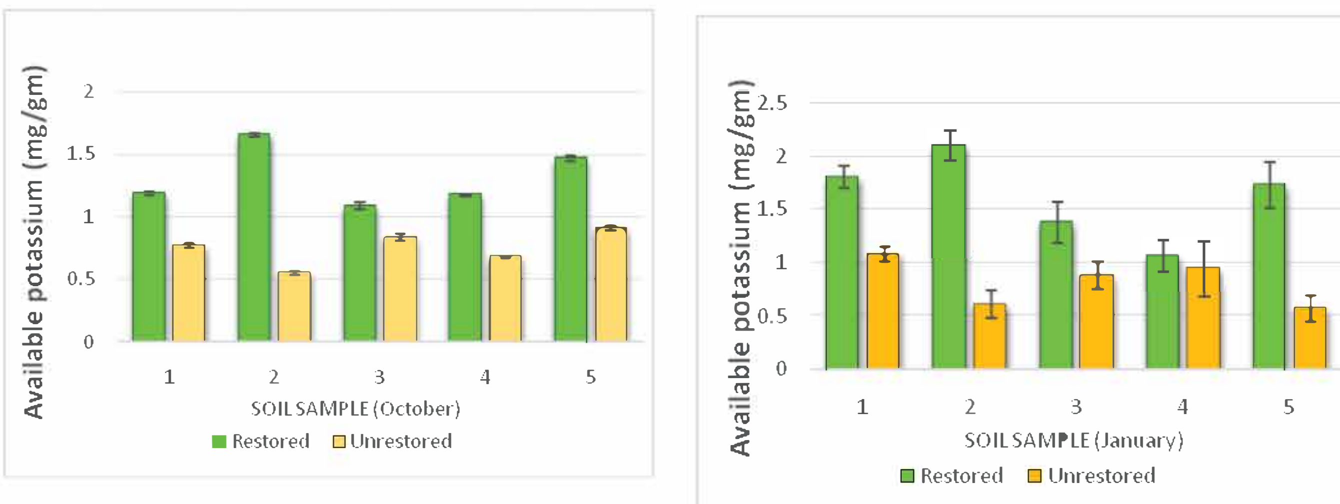

Fig. 11. Available Potassium of Restored and Unrestored Soil Samples

significant difference was found (Fig. 10). Allotey *et al.* (2008) also reported similar range of results of calcium and magnesium. According to Springett and Syers (1984) higher level of calcium is attributed to higher pH of the soil. This could be the reason behind increased amount of calcium than magnesium in our present study.

Available Potassium

Potassium plays an essential role in majority of physiological process. Potassium is also very important to plant growth for protein synthesis to maintain the plant water balance (Addis and Abebaw 2015). Results of our present study showed that there was a significance difference ($p<0.05$) between the samples of restored and unrestored soil in both the months (Fig. 11). Raheb and Heidari (2012) also found similar range of available potassium.

Conclusions

It can be concluded that the pH and EC of the unrestored soil were found to be higher than the restored soil which is good for the soil quality. Decrease in the amount of magnesium does not affect the soil quality because calcium and magnesium are the secondary nutrients as plant requires them in very small amount. On the other hand, increase in primary nutrients like organic carbon and matter, total nitrogen, available phosphorous, available potassium regulates plant growth and crop yield. The increase in soil moisture content and water holding capacity is also interrelated with the amount of organic matter in soil. Thus, it can be seen that restoration has solved the environmental problems on a large scale in Chaksu Block. The restoration program has been a great success in improving rural conditions. Therefore, such type of land restoration projects should also be used for other villages.

References

Addis, W., Abebaw, A. (2015) Analysis of selected physicochemical parameters of soils used for cultivation of garlic (*Allium sativum L.*). *J Sci Technol* **3**(4): 29-35.

Adeleye, E. O., Ayeni, L. S., Ojeniyi, S. O. (2010) Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on alfisol in southwestern Nigeria. *Am J Sci* **6**(10): 871-878.

Adhikari, D. S., B. S. Adhikari. (2007) Veneration of a deity by restoration of sacred grove in a village Minar, Kumaun Region of Uttarakhand: A Case Study. *Am J Sci* **3**: 45-49.

Akpoveta, V. O., S. A. Osakwe, O. K. Ize- Iyamu, W. O. Medjor, F. Egharevba. (2014) Post flooding effect on soil quality in Nigeria: The Asaba, Onitsha Experience. *OJSS*, **4**:72-80.

Allotey, D. F. K., Asiamah, R. D., Dedzoe, C. D., Nyamekye, A. L. (2008) Physico-chemical properties of three salt-affected soils in the lower Volta Basin and management strategies for their sustainable utilization. *West Afr J Appl Ecol* **12**(1) https://doi.org/10.4314/wajae.v12i1.45776.

Ano, A. O., S. A. Odomentam, P.O Ekwueme. (2007) Lead and Cadmium Levels on Soils and cassava (Manihot Esculenta Grantz) along Enugu Port Harcourt Expressway in Nigeria. *Elec J Env Agricult Food Chem* **6**: 2024-2031.

Bordoloi, R., Das, B., Yam, G., Pandey, P. K., Tripathi, O. P. (2019) Modelling of water holding capacity using readily available soil characteristics. *Agric Res* **8**(3):347-355.

Bruce, R. C., Rayment, G. E. (1982) Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land use surveys. *Queensland Department of Primary Industries.*

Deb, P., Debnath, P., Pattanaaik, S. K. (2014) Physico-chemical properties and water holding capacity of cultivated soils along altitudinal gradient in South Sikkim, India. *Indian J Agric Res* **48**(2):120-126.

Dhar, O. N., Rakhecha, P. R., Mandal, B. N., Sangam, R. B. (1982) Was the July 1981 rainstorm over Rajasthan unprecedented. *Pure Appl Geophys* **120**(3)**:** 483-494.

Dilip, S., L. B. Singha, M. L. Khan (2013) Changes in soil physico-chemical parameter of *Dendrocalamus hamiltonii Nees* and *Melocanna baccifera (Roxb.)* Kurz forests during pre-flowering, flowering and post flowering phases in Eastern Himalayas, India. *IOSR J Environ Sci Toxicol Food Technol* **7**: 11-16.

Dobson, A. P., Bradshaw, A. D., Baker, A. Á. (1997) Hopes for the future: restoration ecology and conservation biology. *Science* **277**(5325)**:**515-522.

Ganorkar, R. P., Chinchmalatpure, P. G. (2013) Physicochemical assessment of soil in Rajura Bazar in Amravati district of Maharastra (India). *IJCEPR* **4**(2&3): 46-49.

Gee, G. W., J. W. Bauder (1986) Particle-size analysis. In A Klute (ed.) Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods. Agronomy Monograph No. **9** (2ed)**.** *Soil Sci Soc Am J* WI, 383-411.

Haby, V. A., Russelle, M. P., Skogley, E. O. (1990) Testing soils for potassium, calcium, and magnesium. *Soil Sci Plant Anal* **3**:181-227.

Igwe, C. A., K. Stahr (2004) Water stable Aggregates of flooded Inceplicolis from South- Eastern Nigeria in Relation to mineralogy and chemical Properties. *Aust J Soil Res* **42**: 171-179.

Jackson, M. L. (1973) Soil chemical analysis. *Prentice Hall of India Pvt. Ltd, New Delhi.*

Johnson, D. L., Ambrose, S. H., Bassett, T. J., Bowen, M. L., Crummey, D. E., Isaacson, J. S., Winter-Nelson, A. E. (1997) Meanings of environmental terms. *J Environ Qual* **26**(3)**:** 581-589.

Maharana, J. K., A. M. Patel (2013) Characterization of Physio-chemical Properties and their Impact on Enzyme Activities in a chrono sequence Coal Mine Overburden Spoil as Biomarker of Reclamation process. *J Bacteriol Parasitol* **4**:4.

Maiti, S. K. (2003) Analysis of Chemical Parameters of Soil (Chapter 10 and 11) in book, Handbook of Methods in Environmental Studies: Air, Noise, Soil and Overburden analysis. *ABD Publishers, Jaipur, India* **2**:141-209.

Miller, C. E., L. M. Turk (2002) *Fundamental of soil science. Biotech. Books, Delhi*, 157.

Mishra, R. and Puri, G. S. (1954). Indian manual of plant ecology. The English Book Depot, Dehradun

Ogbodo, E. N. (2011) Assessment of some Soil quality characteristics of Abakaliki urban flood plains of south-east Nigeria, for sustainable crop production. *World J Agric Res* **7**:489-495.

Olsen, S. R., C. V. Cole, F. S. Watanabe, L. A. Dean (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular **939**:1-19. *Gov. Printing Office Washington D.C.*

Onweremadu, E. U., G. E. Osiyi, E. T. Eshett, C. C. Okpara, I. I. Ibeawuchi (2007) Characterization of owner Managed Farms of abia and Imo States for Sustainable crop Production in South Eastern Nigeria. *Am J Sci* **3**:28-37.

Raheb, A., Heidari, A. (2012) Effects of clay mineralogy and physico-chemical properties on potassium availability under soil aquic conditions. *J Soil Sci Plant Nutr* **12**(4):747-761.

Rai, S., A. K. Chopra, C. Pathak, D. K. Sharma, R. Sharma, P. M. Gupta (2011) Comparative Study of some physiochemical parameter of soil irrigated with sewage water and canal water of Dehradun city. *Arch Appl Sci Res* **3**:318-315.

Redman, C. L. (1999) *Human impact on ancient environments.* University of Arizona Press.

Saravanakumar, A., Rajkumar, M., Serebiah, J. S., Thivakaran, G. A. (2008) Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat. *J Environ Biol* **29**(5):725-732.

Sarwar, M. A., M. Ibrahim, M. Tahir, K. Ahmad, Z. I. Khan, E. E. Valeem (2010) Appraisal of press mud and inorganic fertilizers on soil properties, yield and sugarcane quality. *Pak J Bot* **42**: 1361-67.

SER (2004) The SER Primer on Ecological Restoration, Version 2. Society for Ecological Restoration Science and Policy Working Group.

Solanki, H. A., Chavda, N. H. (2012) Physico-chemical analysis with reference to seasonal changes in soils of Victoria park reserve forest, Bhavnagar (Gujarat). *Life Sci Leafl* **30**: 62-68.

Springett, J. A., Syers, J. K. (1984) Effect of pH and calcium content of soil on earthworm cast production in the laboratory. *Soil Biol Biochem* **16**(2): 185-189.

Wagh, G. S., Chavhan, D. M., Sayyed, M. R. G. (2013) Physicochemical Analysis of Soils from Eastern Part of Pune City. *Univers J Environ Res Technol* **3**(1): 93-99.

Walkley, A., Black, I. A. (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci* **37**(1)**:** 29-38.