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Research Article

GREEN AUDIT – A HOLISTIC APPROACH FOR SUSTAINABLE DEVELOPMENT

CHANDAN SAHU[1]*, ADITYA KUMAR SINGH[1], SRADHANJALI BASTI[1], ANITA MOHANTY[1], PIPASA ACHARYA[1], HEMENDRA NATH NAYAK[2] AND SANJAT KUMAR SAHU[1]

[1]P.G. Department of Environmental Sciences, Sambalpur University, Jyoti Vihar – 768019, India.

[2]Regional Office, State Pollution Control Board, Sambalpur, India.

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ABSTRACT

Optimum resource utilization with minimal environmental disturbance is a key strategy adopted by any organization to successfully achieve its vision and mission. Green audit therefore becomes an integral part to review the planning and its implementation in various aspects of the functionalities of an organization which not only helps strengthen the internal working environment of the organization but also eradicates many bottlenecks in the form of abnormal operational practices and unnecessary economic loads. Evaluation of impacts on the natural resources within the premises due to the routine activities of the organization also adds a value to the sustainable development of the organization. The present evaluation of the environmental resources (air, water, soil) of Sambalpur University, Jyoti Vihar was therefore carried out to study the impact of the institutional activities on these resources. The results revealed that the air, water and soil quality besides noise level are well within the prescribed limit and hence the university can be considered as a green and serene place with ideal environment for higher education as on today. However, continuous and regular monitoring of the environmental quality in future is important to ensure the development with the green practice inside the campus.

INTRODUCTION

Sustainability is becoming an integral part of the global resource management technique and the key approach to this management involves a proper input, output and life-cycle analysis involving various stages of verification that can be obtained through environmental audit. Environmental audit is a systematic, documented and objective oriented approach to verify the evidences pertaining to various environmental aspects. It is a useful management tool to identify and periodically inspect the environmental aspects to make an organization eco-friendly. Performing an audit can also help facilitate the intervening process (Owoeye and Okojie, 2013).

A good environment management policy requires that there should be constant efforts to analyze and monitor various organizational working systems and processes, to generate and transmit this information for the inspecting authority (Mehta and Sharma, 1997). Environmental audit is generally practiced by inviting an external body to the particular organization to inspect the documents, records and performance of the organizations through mock drills, questionnaires and on-site practice verification. Environmental audit helps in communicating the results of this process to the concerned management and suggests corrective steps to be followed at the early stage (Chaudhury, 2002). However, self audit by an organization comprising of the internal members directly associated with the organization from various sub departments and backgrounds can also help the organization to assess its own performance and enhance the value of an audit (Williams, 1992).

***Corresponding authors email: cks.env@gmail.com**

It aims not only at minimizing potential negative impacts of the organization on the environment but also at maximizing the positive impacts of an environmentally sound system of the organization's activities (Rao, *et al*., 2011).

Green audit, constituted in the year 1992, aims at providing answers to all the stakeholders and interested parties about the environmental performance and threats arising due to operational practice against the health and environment of the surrounding areas of an organization. It is an examination of what an organization is doing to prevent its operational activities from harming the environment (Goswami, 2012; Gupta and Shukle, 2006). It is therefore important to have an adequate knowledge regarding the working conditions of an area and the threats associated with it. Several audit parties take a close look regarding these aspects that ultimately lead to a deterioration of the health of the biota and the environment surrounding the organization.

Green audit is a holistic perspective of looking into the totality of the actions towards greening the organization and is foremost reflected in its policies alongside the organization's profile (Ogoc, 2015). Sambalpur University being an educational institution is considered under sensitive zone and hence it requires a periodic examination of the environmental conditions to test whether it is conducive or other necessary steps are to be taken to bring it into ecofriendly form which can include green cover, finding alternative energy resource, prohibition of petrol driven vehicles inside the campus etc. The present study was confined to the monitoring of air, water and soil quality and noise level inside the Sambalpur university campus of Odisha, India.

MATERIALS AND METHODS

Geographical Location of the Study Site

The study was undertaken inside the campus of Sambalpur University, namely Jyoti Vihar, located in the eastern part of India and lies between the coordinates of 21˚28′50.03′′ N and 83˚53′01.88′′ E with an elevation of 177 m above MSL.

Sampling Period and Frequency

The sampling was carried out at bimonthly intervals during November and January, March and May, and July and September, spreading over the period from 2016 – 2017, representing three seasons, i.e., post monsoon, pre monsoon and monsoon respectively. The air sampling with respect to ambient air quality and noise level was carried out twice a week (i.e., eight in a month) totaling to 16 sampling days per season whereas, the water and soil sampling was carried out twice (i.e., once in each month) in the respective seasons and an average data of each analysis has been presented in the respective tables.

Ambient Air Quality Analysis

The air quality monitoring was done at two stations of the Sambalpur University campus, one in the academic area (at top of the Department of Environmental Sciences) and the other in the residential area (at top of the Qr. No. C – 9) through a Respirable Dust Sampler (RDS) for SO_2, NO_2 and PM_{10} and through a Fine Particulate Sampler (FPS) for $PM_{2.5}$ following the procedure of standard method and sampling duration. On the whole as prescribed by CPCB (2009) the parameter SO_2 was measured by improved West and Geake method, NO_2 was measured by modified Jacob and Hochheiser method and PM_{10} and $PM_{2.5}$ were measured by Gravimetric method.

Water Quality Analysis

Various physicochemical parameters were tested from different water sources like bore wells, dug wells and tap waters (supplied from Public Health Department) of the Sambalpur University campus. The analysis of various parameters was carried out as per the method of APHA (1989). The list of various parameters analyzed along with their methodology has been given in Table 1.

Table 1. Methodologies used for analysis of various water quality parameters.

S. No.	Parameters	Methodology
1.	Temperature	Clinical Thermometer
2.	pH	Digital pH meter
3.	Conductivity	Digital Conductivity meter
4.	Turbidity	Nephlo-turbidity meter
5.	TDS, TSS, TS	Oven dry method
6.	Dissolved Oxygen	Winkler's method
7.	Chemical Oxygen Demand	Reflux Condenser method
8.	Sulphate	Titrimetric method
9.	Chloride	Potassium Chromate method
10.	Free Carbon dioxide	Titrimetric method
11.	Total Alkalinity	Titrimetic method
12.	Total Acidity	Titrimetric method
13.	Total Hardness	EDTA titrimetic method
14.	Nitrate	Phenoldisulphonic acid method
15.	Phosphate	Ammonium molybdate method
16.	K, Na	Flame photometric method

Soil Quality Analysis

The soil quality of various land use viz. agriculture, pasture, forest and garden inside the campus of Sambalpur University were studied for various parameters like temperature, moisture, pH, conductivity, organic carbon and organic matter, potassium, nitrate and phosphate as per the method described by Hesse (1971), where as CO_2 evolution from soil (otherwise called soil respiration) was studied following the method of Witkamp (1966). The detailed methodology used for analysis of these parameters has been given in Table 2.

Noise Quality Monitoring

Since the noise activities inside the campus gives a reflection of the environmental condition prevailing in the area, the noise levels at various locations (Administrative Block, Ladies Hostel compound, Boys' Hostel compound and Residential Block) inside the Sambalpur University campus were also monitored with a noise level meter (Bruce, 1972).

RESULTS AND DISCUSSION

Air Quality Analysis

Table 3 presents the ambient air quality data of gaseous and particulate pollutants in the academic and residential area inside the Sambalpur University campus (Jyoti Vihar). The value of SO_2 ranged between 3.1 and 3.7 $\mu g/m^3$ in the academic area, while that in the residential area it was in the range of 3.4 to 4.1 $\mu g/m^3$. So far NO_2 is concerned; it varied from 13.9 to 16.0 $\mu g/m^3$ in the academic area and 11.3 to 14.4 $\mu g/m^3$ in the residential area. Similarly PM_{10} varied from 96.8 to 146.4 $\mu g/m^3$ and 64.1 to 86.2 $\mu g/m^3$, and $PM_{2.5}$ varied from 52.3 to 84.3 $\mu g/m^3$ and 49.4 to 59.2 $\mu g/m^3$ in the academic area and residential area, respectively.

Table 2. Methodologies used for analysis of various soil quality parameters.

S. No.	Parameters	Methodology
1.	Soil Temperature	Soil Thermometer method
2.	Soil Moisture	Oven dry method
3.	Soil pH	Digital pH meter
4.	Soil Conductivity	Digital Conductivity meter
5.	Organic carbon and Organic Matter	Walkley and Black's rapid titrimetric method
6.	Nitrate	Phenol disulphonic acid method
7.	Phosphate	Ammonium Molybdate Method
8.	Potassium	Flame photometric method
9.	CO_2 Evolution (soil respiration)	Inverted Jar Method

It can be observed from the above table that the values of the gaseous pollutants (SO_2 and NO_2) are well within the prescribed NAAQ (National Ambient Air Quality Standard, 2009) limit in both the academic and residential areas in all seasons. The particulate matter (PM_{10} and $PM_{2.5}$) values, on the other hand, are exceeding the permissible limit in the academic area, but are within the limit in the residential area. The rise in particulate matter can be attributable to the construction work going inside the campus during the concerned period for the infrastructural expansion of the academic area. However, this constructional work did not affect the particulate matter concentration of the residential area inside the campus which might be due to the presence of a hillock forest ecosystem with thick green covers separating the academic area from that of residential area and restricting the transportation of PM through the air (Das and Prasad, 2012; Sahu and Sahu, 2015). It is also observed that all the analyzed parameters of ambient air quality were within the permissible limit in both the academic as well as residential areas during the monsoon season which might have been because of the masking affect of the precipitation and lesser number of constructional activities during this period.

Water Analysis

In the present study, water samples from bore wells, dug wells and taps (supplied from public health

Table 3. Ambient air quality ($\mu g/m^3$) at various sampling locations of Sambalpur University campus during different seasons of 2016-17.

Seasons	Sampling Location	SO_2	Std	NO_2	Std	PM_{10}	Std	$PM_{2.5}$	Std
Post Monsoon	Academic Area	3.7	80	15.6	80	112.3	100	66.1	60
	Residential Area	3.9		11.3		72.4		54.1	
Pre-Monsoon	Academic Area	3.8		16.0		146.4		84.3	
	Residential Area	4.1		14.4		86.2		59.2	
Monsoon	Academic Area	3.1		13.9		96.8		52.3	
	Residential Area	3.4		12.1		64.1		49.4	
Average	Academic Area	3.5		15.2		118.5		67.6	
	Residential Area	3.8		12.6		74.2		54.2	

department) were taken in three seasons and were analyzed for various physicochemical and biological parameters. Tables 4, 5 and 6 represent water quality analysis with respect to various physicochemical parameters of bore well, dug well and tap water, respectively, while Table 7 shows a comparison of the water quality of various samples with the drinking water standard (IS 10500).

The temperature ranged from 24.6 – 26.1° C in the bore well water samples, while that in the dug well and tap water samples it was in the range between

Table 4. Water quality analysis of bore well inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre-Monsoon	Monsoon	Range	Mean ± SD
Temperature (°C)	25.6	26.1	24.6	24.6 – 26.1	25.43 ± 0.76
pH	7.3	7.4	7.1	7.1 – 7.4	7.27 ± 0.15
Conductivity (µS/cm)	138.6	148.4	122.8	122.8 – 148.4	136.60 ± 12.92
Turbidity (NTU)	1	1	1.8	1 – 1.8	1.27 ± 0.46
TDS (mg/L)	94	102	84	84 - 102	93.33 ± 9.02
TSS (mg/L)	18	14	22	14 - 22	18.00 ± 4.00
TS (mg/L)	112	116	106	106 - 116	111.33 ± 5.03
DO (mg/L)	8.5	7.8	8.9	7.8 – 8.9	8.40 ± 0.56
COD (mg/L)	18	28	20	20 - 30	23.33 ± 5.77
Sulphate (mg/L)	4.56	4.86	4.24	4.24 – 4.86	4.55 ± 0.31
Chloride (mg/L)	13.6	16.5	12.4	12.4 – 16.5	14.17 ± 2.11
Free CO_2 (mg/L)	2.81	1.91	3.49	1.91 – 3.49	2.74 ± 0.79
Total Alkalinity (mg $CaCO_3$/L)	28	24	22	22 - 28	24.67 ± 3.06
Total Acidity (mg $CaCO_3$/L)	8.8	9.2	9.9	8.8 – 9.9	9.30 ± 0.56
Total Hardness (mg $CaCO_3$/L)	24	20	16	16 - 24	20.00 ± 4.00
Nitrate (mg/L)	3.56	4.14	3.18	3.18 – 4.14	3.63 ± 0.48
Phosphate (mg/L)	0.74	0.84	0.67	0.67 – 0.84	0.75 ± 0.09
Potassium (mg/L)	2.62	2.42	2.14	2.14 – 2.62	2.39 ± 0.24
Sodium (mg/L)	1.12	1.14	0.96	0.96 – 1.14	1.07 ± 0.10

Table 5. Water quality analysis of dug well inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre-Monsoon	Monsoon	Range	Mean ± SD
Temperature (°C)	25.2	27.8	24.8	24.8 – 27.8	25.93 ± 1.63
pH	7.5	7.6	7.4	7.4 – 7.6	7.50 ± 0.10
Conductivity (µS/cm)	166.3	174.2	152.8	152.8 – 174.2	164.43 ± 10.82
Turbidity (NTU)	1	2	2.2	1 – 2.2	1.73 ± 0.64
TDS (mg/L)	112	118	104	104 – 118	111.33 ± 7.02
TSS (mg/L)	22	18	28	18 – 28	22.67 ± 5.03
TS (mg/L)	134	136	132	132 – 136	134.00 ± 2.00
DO (mg/L)	8.4	8.2	9.2	8.2 – 9.2	8.60 ± 0.53
COD (mg/L)	30	20	20	20 – 30	23.33 ± 5.77
Sulphate (mg/L)	5.86	6.78	5.24	5.24 – 6.78	5.96 ± 0.77
Chloride (mg/L)	16.4	18.6	12.8	12.8 – 18.6	15.93 ± 2.93
Free CO_2 (mg/L)	1.76	1.72	1.91	1.72 – 1.91	1.80 ± 0.10
Total Alkalinity (mg $CaCO_3$/L)	28	34	24	24 – 34	28.67 ± 5.03
Total Acidity (mg $CaCO_3$/L)	9.2	8.6	9.7	8.6 – 9.7	9.17 ± 0.55
Total Hardness (mg $CaCO_3$/L)	28	24	22	22 - 28	24.67 ± 3.06
Nitrate (mg/L)	3.56	4.18	3.12	3.12 – 4.18	3.62 ± 0.53
Phosphate (mg/L)	1.68	1.46	0.96	0.96 – 1.68	1.37 ± 0.37
Potassium (mg/L)	2.84	2.56	2.46	2.46 – 2.84	2.62 ± 0.20
Sodium (mg/L)	1.38	1.46	1.24	1.24 – 1.46	1.36 ± 0.11

Table 6. Water quality analysis of tap water inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre Monsoon	Monsoon	Range	Mean ± SD
Temperature (°C)	24.9	26.6	25.4	24.9 – 26.6	25.63 ± 0.87
pH	7.4	7.4	7.3	7.3 – 7.4	7.37 ± 0.06
Conductivity (µS/cm)	148.6	152.6	146.8	146.8 – 152.6	149.33 ± 2.97
Turbidity (NTU)	1	1.5	2	1 – 2	1.50 ± 0.50
TDS (mg/L)	102	106	98	98 – 106	102.00 ± 4.00
TSS (mg/L)	18	16	20	16 - 20	18.00 ± 2.00
TS (mg/L)	120	122	118	118 – 122	120.00 ± 2.00
DO (mg/L)	8.2	7.2	8.4	7.2 – 8.4	7.93 ± 0.64
COD (mg/L)	28	25	20	20 – 25	25.00 ± 5.00
Sulphate (mg/L)	5.78	6.46	6.24	5.78 – 6.46	6.16 ± 0.35
Chloride (mg/L)	22	18.5	14.5	14.5 – 22	18.33 ± 3.75
Free CO_2 (mg/L)	2.06	2.22	2.4	2.06 – 2.4	2.23 ± 0.17
Total Alkalinity (mg $CaCO_3$/L)	26	28	24	24 – 28	26.00 ± 2.00
Total Acidity (mg $CaCO_3$/L)	9.4	9.3	9.6	9.3 – 9.6	9.43 ± 0.15
Total Hardness (mg $CaCO_3$/L)	30	28	24	24 – 30	27.33 ± 3.06
Nitrate (mg/L)	3.74	4.26	3.24	3.24 – 4.26	3.75 ± 0.51
Phosphate (mg/L)	1.26	1.34	1.08	1.08 – 1.34	1.23 ± 0.13
Potassium (mg/L)	2.74	2.98	2.34	2.34 – 2.98	2.69 ± 0.32
Sodium (mg/L)	1.22	1.26	1.18	1.18 – 1.26	1.22 ± 0.04

Table 7. Comparison of water quality of various samples with BIS standard.

Variables	Bore Well Water		Dug Well Water		Tap Water		BIS Standards (IS 10500)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Acceptable Limit	Permissible Limit
Temperature (°C)	24.6 – 26.1	25.43 ± 0.76	24.8 – 27.8	25.93 ± 1.63	24.9 – 26.6	25.63 ± 0.87	-	-
pH	7.1 – 7.4	7.27 ± 0.15	7.4 – 7.6	7.50 ± 0.10	7.3 – 7.4	7.37 ± 0.06	6.5 - 8.5	No Relaxation
Conductivity (µS/cm)	122.8 – 148.4	136.60 ± 12.92	152.8 – 174.2	164.43 ± 10.82	146.8 – 152.6	149.33 ± 2.97	-	-
Turbidity (NTU)	1 – 1.8	1.27 ± 0.46	1 – 2.2	1.73 ± 0.64	1 – 2	1.50 ± 0.50	1	5
TDS (mg/L)	84 - 102	93.33 ± 9.02	104 – 118	111.33 ± 7.02	98 – 106	102.00 ± 4.00	500	2000
TSS (mg/L)	14 - 22	18.00 ± 4.00	18 – 28	22.67 ± 5.03	16 - 20	18.00 ± 2.00	-	-
TS (mg/L)	106 - 116	111.33 ± 5.03	132 – 136	134.00 ± 2.00	118 – 122	120.00 ± 2.00	-	-
DO (mg/L)	7.8 – 8.9	8.40 ± 0.56	8.2 – 9.2	8.60 ± 0.53	7.2 – 8.4	7.93 ± 0.64	-	-
COD (mg/L)	20 - 30	23.33 ± 5.77	20 – 30	23.33 ± 5.77	20 – 25	25.00 ± 5.00	-	-
Sulphate (mg/L)	4.24 – 4.86	4.55 ± 0.31	5.24 – 6.78	5.96 ± 0.77	5.78 – 6.46	6.16 ± 0.35	200	400
Chloride (mg/L)	12.4 – 16.5	14.17 ± 2.11	12.8 – 18.6	15.93 ± 2.93	14.5 – 22	18.33 ± 3.75	250	1000
Free CO_2 (mg/L)	1.91 – 3.49	2.74 ± 0.79	1.72 – 1.91	1.80 ± 0.10	2.06 – 2.4	2.23 ± 0.17	-	-
Total Alkalinity (mg $CaCO_3$/L)	22 - 28	24.67 ± 3.06	24 – 34	28.67 ± 5.03	24 – 28	26.00 ± 2.00	200	600
Total Acidity (mg $CaCO_3$/L)	8.8 – 9.9	9.30 ± 0.56	8.6 – 9.7	9.17 ± 0.55	9.3 – 9.6	9.43 ± 0.15	-	-
Total Hardness (mg $CaCO_3$/L)	16 - 24	20.00 ± 4.00	22 - 28	24.67 ± 3.06	24 – 30	27.33 ± 3.06	200	600
Nitrate (mg/L)	3.18 – 4.14	3.63 ± 0.48	3.12 – 4.18	3.62 ± 0.53	3.24 – 4.26	3.75 ± 0.51	45	No Relaxation
Phosphate (mg/L)	0.67 – 0.84	0.75 ± 0.09	0.96 – 1.68	1.37 ± 0.37	1.08 – 1.34	1.23 ± 0.13	-	-
Potassium (mg/L)	2.14 – 2.62	2.39 ± 0.24	2.46 – 2.84	2.62 ± 0.20	2.34 – 2.98	2.69 ± 0.32	-	-
Sodium (mg/L)	0.96 – 1.14	1.07 ± 0.10	1.24 – 1.46	1.36 ± 0.11	1.18 – 1.26	1.22 ± 0.04	-	-

24.8 – 27.8 and 24.9 – 26.6° C respectively with highest temperature found in dug well water (27.8° C) during pre monsoon and lowest temperature was observed in bore well water (24.6° C) during monsoon. In

majority of the cases, the pH of water samples were found to be in near alkaline region ranging from 7.1 – 7.4, 7.4 – 7.6 and 7.3 - 7.4 in bore well, dug well and tap water samples respectively with minimum pH being 7.1 of bore well water during monsoon and maximum pH being 7.6 of dug well water during pre monsoon. Temperature and pH directs many reactions in a water body. Similarly, conductivity is a measure of the ionic concentration of water which increases with pollution. Conductivity in all water samples was maximum in monsoon and minimum in post monsoon. It ranged from 122.8 – 148.4 µS/cm in the bore well samples, 152.8 – 174.2 µS/cm in the dug well samples and 146.8 – 152.6 µS/cm in the tap water samples. The results for temperature, pH and conductivity were found well within the prescribed standard (Table 7).

The turbidity of all the water samples ranged from 1 to 2.2 NTU thereby suggesting that the water samples were free from any sort of turbid materials. Similarly the TDS and TSS values ranged from 84 – 102 and 106 – 116, 104 – 118 and 18 – 28, 98 – 106 and 16 – 20 mg/L in bore well, dug well and tap water samples respectively. The total dissolved solid (TDS) is a measure of the salt content in water. The maximum TDS was found in dug well water (118 mg/L) during pre monsoon and minimum TDS was found in bore well water (84 mg/L) during monsoon whereas, the maximum total suspended solids (TSS) was found in dug well water (28 mg/L) during monsoon season and minimum TSS was found in bore well water (14 mg/L) during pre monsoon season. Total Solids (TS) is a measure of TDS and TSS and hence the highest TS was found in dug well water (136 mg/L) during pre monsoon and minimum TS was found in bore well water (106 mg/L) during monsoon season.

The dissolved oxygen (DO) and chemical oxygen demand (COD) represents the organic matter pollution of water body and therefore reflects whether water is fit for use or not (Basti, *et al*., 2015). The DO content ranged from 7.8 – 8.9, 8.2 – 9.2 and 7.2 – 8.4 mg/L in bore well, dug well and tap water respectively with the highest value in dug well water (9.2 mg/L) during monsoon season and lowest in tap water (7.2 mg/L) during pre monsoon. On the other hand the COD ranged from 20 – 30, 20 – 30 and 20 – 25 mg/L in bore well, dug well and tap water samples respectively with the highest value in dug well water (30 mg/L) during post monsoon and the minimum value in bore well water (18 mg/L) during post monsoon season. This indicates that all the water sources of Sambalpur University campus is fit for consumption.

The values of sulphate, chloride and free CO_2 ranged from 4.24 – 4.86, 12.4 – 16.5 and 1.91 – 3.49 mg/L in the bore well samples, while that in the dug well and tap water samples were in the range of 5.24 – 6.78, 12.8 – 18.6 and 1.72 – 1.91 and 5.78 – 6.46, 14.5 – 22 and 2.06 – 2.4 mg/L, respectively. The maximum value for the sulphate was found in dug well water (6.78 mg/L) during pre monsoon while the minimum value was obtained in bore well water (4.24 mg/L) during monsoon season. Chloride imparts salinity to water beyond a limit and hence is important in water quality analysis. The highest chloride was found in tap water (22 mg/L) during post monsoon and minimum chloride was found in bore well water (12.4 mg/L) during monsoon season. The values for sulphate and chloride were well within the permissible limit (Table 7). The high value for free CO_2 was found in bore well water sample (3.49 mg/L) during monsoon and the lowest value of free CO_2 was found in dug well water sample (1.72 mg/L) during pre monsoon.

Alkalinity is the measure of the amount of acid required to neutralize the water which is primarily imparted by hydroxyl, carbonate and bicarbonate ions. Conversely acidity is the measure of amount of base required to neutralize the water sample. Temporary hardness is also a measure of the amount of carbonate and bicarbonate ions present in water. The water samples when analyzed for total alkalinity, ranged from 22 – 28, 24 – 34 and 24 – 28 mg/L in bore well, dug well and tap water, respectively. The highest value of it was found in dug well water (34 mg/L) during pre monsoon and the lowest value was found in bore well water (22 mg/L) during monsoon season. Similarly, acidity ranged from 8.8 – 9.9, 8.6 – 9.7 and 9.3 – 9.6 mg/L in bore well, dug well and tap water samples, respectively. The maximum acidity was found in bore well water (9.9 mg/L) during monsoon and minimum acidity was found in dug well water (8.6 mg/L) during pre monsoon season. When analyzed for the total hardness, the value ranged from 16 – 24, 22 – 28 and 24 – 30 mg/L in bore well, dug well and tap water samples respectively. Maximum total hardness was found in tap water (30 mg/L) during post monsoon and minimum value of it was found in bore well water (16 mg/L) during monsoon season. The values of total alkalinity and hardness were also within the permissible limits for all water samples.

The excessive nutrients in the water body provide an ideal condition for aquatic organisms which subsequently leads to organic matter pollution. The nutrients also bring many health hazards when they enter into the human body. Hence the water samples

were analyzed for various nutrients like nitrate, phosphate, potassium and sodium. While the values of nitrate and phosphate ranged from 3.18 – 4.14 and 0.67 – 0.84 mg/L in the bore well samples, 3.12 – 4.18 and 0.96 – 1.68 mg/L in the dug well samples, 3.24 – 4.26 and 1.08 – 1.34 mg/L in the tap water samples, that of the values for sodium and potassium ranged from 2.14 – 2.62 and 0.96 – 1.14 mg/L in the bore well, 2.46 – 2.84 and 1.24 – 1.46 mg/L in the dug well, 2.34 – 2.98 and 1.18 – 1.26 mg/L in tap water samples, respectively. The maximum nitrate was found in tap water (4.26 mg/L) during pre monsoon season while the minimum nitrate was found in dug well water (3.12 mg/L) during monsoon. These values for all the water samples were within the permissible limit. Similarly, the highest value for the phosphate content was found in dug well water (1.68 mg/L) during post monsoon and the lowest value was found in bore well water (0.67 mg/L) during monsoon season. In the case of potassium, the maximum value for potassium was found in dug well water (2.98 mg/L) during pre monsoon and minimum value was found in bore well water (2.14 mg/L) during monsoon season. Sodium content however varied from 0.96 - 1.46 mg/L with the dug well water was on the higher side during pre monsoon and the bore well water was on the lower side during monsoon season.

When all the water samples were tested for their biological parameters, it was observed that the coliforms count and the E. coli count were nil thereby suggesting that the water from all sources are completely safe for drinking. Further, when all the measured parameters were compared with that of the national standard, it was revealed that all the water sources of Sambalpur University campus are well within the prescribed potable water standard and hence safe for drinking and other uses (Table 7).

Soil Analysis

In the present study, soil samples from various land use practices viz. agricultural, pasture, forest and garden soil were taken in three seasons and were analyzed for various physicochemical parameters and soil metabolic (CO_2 evolution) activities and the results are given in Tables 8-11.

Soil temperature and moisture governs many physicochemical and biological properties of soil (Sahu, *et al*., 2016a; Sahu, *et al*., 2016b). The values of soil temperature ranged from 26.2 – 33.4, 27.6 – 36.8, 26.4 – 31.2 and 29.4 – 34.8° C in agricultural, pasture, forest and garden soil, respectively. The maximum soil temperature was observed in pasture land (36.8° C) during the pre monsoon season and the minimum soil temperature was observed in agricultural land (26.4° C) during the monsoon season. Similarly, the soil moisture ranged from 24.39 – 36.42, 8.23 – 20.14, 14.64 – 32.46 and 16.24 – 28.14% in agricultural, pasture, forest and garden soil, respectively. The highest value for soil moisture was found in agricultural land (36.42%) during the monsoon season while the lowest value was found in pasture land (8.23%) during the pre monsoon.

In majority of the cases, the soil pH was in the near acidic region or slightly alkaline region ranging from 6.28 – 6.76 in agricultural soil, 7.42 – 7.86 in pasture soil, 6.98 – 7.24 in forest soil and 6.46 – 6.63 in garden soil with minimum pH being 6.28 in agricultural soil during the monsoon season and maximum pH being 7.86 in the pasture soil during the post monsoon season. A gradual increase in the soil conductivity was seen with the change in season from pre monsoon to monsoon followed by a decrease in post monsoon. Soil conductivity ranged from 138.8 – 164.4 µS/cm in agricultural soil, 109.8 – 126.6 µS/cm in pasture soil,

Table 8. Analysis of Agricultural soil inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre Monsoon	Monsoon	Range	Mean ± SD
Soil Temperature (°C)	29.7	33.4	26.2	26.2 – 33.4	29.77 ± 3.60
Soil Moisture (%)	29.46	24.39	36.42	24.39 – 36.42	30.09 ± 6.04
Soil pH	6.76	6.43	6.28	6.28 – 6.76	6.49 ± 0.25
Conductivity (µS/cm)	146.5	138.8	164.4	138.8 – 164.4	149.90 ± 13.13
OC (%)	2.32	2.40	2.84	2.32 – 2.84	2.52 ± 0.28
OM (%)	3.99	4.14	4.89	3.99 – 4.89	4.34 ± 0.48
K (mg/kg)	72.18	66.18	84.37	66.18 – 84.37	74.24 ± 9.27
Nitrate (mg/kg)	46.42	38.64	54.82	38.64 – 54.82	46.63 ± 8.09
Phosphate (mg/kg)	12.84	9.96	14.78	9.96 – 14.78	12.53 ± 2.43
CO_2 Evolution (mg of $CO_2/m^2/h$)	1456.65	1384.23	1548.76	1384.23 – 1548.76	1463.21 ± 82.46

Table 9. Analysis of Pasture Soil inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre Monsoon	Monsoon	Range	Mean ± SD
Soil Temperature (°C)	31.3	36.8	27.6	27.6 – 36.8	31. 90 ± 4.63
Soil Moisture (%)	14.38	8.23	20.14	8.23 – 20.14	14.25 ± 5.96
Soil pH	7.86	7.67	7.42	7.42 – 7.86	7.65 ± 0.22
Conductivity (µS/cm)	118.5	109.8	126.6	109.8 – 126.6	118.30 ± 8.40
OC (%)	1.39	1.32	1.53	1.32 – 1.53	1.41 ± 0.11
OM (%)	2.41	2.28	2.64	2.28 – 2.64	2.44 ± 0.18
K (mg/kg)	76.42	68.42	84.64	68.42 – 84 .64	76.49 ± 8.11
Nitrate (mg/kg)	41.67	34.14	48.34	34.14 – 48.34	41.38 ± 7.10
Phosphate (mg/kg)	6.56	6.47	6.84	6.47 – 6.84	6.62 ± 0.19
CO_2 Evolution (mg of $CO_2/m^2/h$)	912.14	898.38	969.45	898.38 – 969.45	926.66 ± 37.69

Table 10. Analysis of Forest Soil inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre-Monsoon	Monsoon	Range	Mean ± SD
Soil Temperature (°C)	28.3	31.2	26.4	26.4 – 31.2	28.63 ± 2.42
Soil Moisture (%)	23.59	14.64	32.46	14.64 – 32.46	23.56 ± 8.91
Soil pH	7.24	7.10	6.98	6.98 – 7.24	7.11 ± 0.13
Conductivity (µS/cm)	124.67	117.3	132.46	117.3 – 132.46	124.81 ± 7.58
OC (%)	3.54	3.42	3.78	3.42 – 3.78	3.58 ± 0.18
OM (%)	6.10	5.89	6.51	5.89 – 6.51	6.17 ± 0.32
K (mg/kg)	89.48	86.14	88.53	86.14 – 89.48	88.05 ± 1.72
Nitrate (mg/kg)	39.35	41.87	44.64	39.35 – 44.64	41.95 ± 2.65
Phosphate (mg/kg)	18.72	14.26	16.43	14.26 – 18.72	16.47 ± 2.33
CO_2 Evolution (mg of $CO_2/m^2/h$)	2024.35	1938.22	2249.68	1938.22 – 2249.68	2070.75 ± 160.83

Table 11. Analysis of Garden Soil inside Sambalpur University campus during different seasons of 2016-17.

Parameters	Post Monsoon	Pre-Monsoon	Monsoon	Range	Mean ± SD
Soil Temperature (°C)	31.5	34.8	29.4	29.4 – 34.8	31.90 ± 2.72
Soil Moisture (%)	20.43	16.24	28.14	16.24 – 28.14	21.60 ± 6.04
Soil pH	6.52	6.63	6.46	6.46 – 6.63	6.54 ± 0.09
Conductivity (µS/cm)	142.8	128.6	136.3	128.6 – 142.8	135.90 ± 7.11
OC (%)	2.38	2.02	2.67	2.02 – 2.67	2.36 ± 0.33
OM (%)	4.1	3.48	4.6	3.48 – 4.6	4.06 ± 0.56
K (mg/kg)	74.32	72.56	78.67	72.56 – 78.67	75.18 ± 3.15
Nitrate (mg/kg)	41.43	38.76	42.89	38.76 – 42.89	41.03 ± 2.09
Phosphate (mg/kg)	14.67	10.08	11.96	10.08 – 14.67	12.24 ± 2.31
CO_2 Evolution (mg of $CO_2/m^2/h$)	1276.12	1211.33	1423.45	1211.33 – 1423.45	1303.63 ± 108.70

117.3 – 132.46 µS/cm in forest soil and 128.6 – 142.8 µS/cm in garden soil respectively. Irrespective of the seasons, the highest conductivity was measured in agricultural soil (164.4 µS/cm) during the monsoon season and the lowest conductivity was measured in the pasture soil (109.8 µS/cm) during the pre monsoon season. Organic carbon and organic matter for agricultural, pasture, forest and garden soil ranged from 2.32 – 2.84 and 3.99 – 4.89; 1.32 – 1.53 and 2.28 – 2.64; 3.42 – 3.78 and 5.89 – 6.51 and 2.02 – 2.67 and 3.48 – 4.6% respectively. The maximum value for OC and OM were obtained in forest soil (3.78 and 6.51% respectively) during the monsoon season and the minimum values were obtained in

pasture soil (1.32% and 2.28% respectively) during the pre monsoon season.

The NPK in soil are considered as the major elements required by the plants. Potassium content ranged from 66.18 – 84.37 mg/kg in agricultural soil, 68.42 – 84.64 mg/kg in pasture soil, 86.14 – 89.48 mg/kg in forest soil and 72.56 – 78.67 mg/kg in garden soil, and that of nitrate and phosphate content ranged from 38.64 – 54.82 and 9.96 – 14.78 mg/kg in agricultural soil, 34.14 – 48.34 and 6.47 – 6.84 mg/kg in pasture soil, 39.35 – 44.64 and 14.26 – 18.72 mg/kg in forest soil and 38.76 – 42.89 and 10.08 – 14.67 mg/kg in garden soil, respectively. Maximum concentration of potassium was recorded in the forest soil (89.48 mg/kg) during the post monsoon and the minimum concentration was recorded in agricultural soil (66.18 mg/kg) during the pre monsoon. Maximum concentration of nitrate was obtained in agricultural soil (54.82 mg/kg) during the monsoon season and the minimum concentration was obtained in pasture soil (34.14 mg/kg) during the pre monsoon. Maximum concentration of phosphate was found in forest soil (18.72 mg/kg) during the post monsoon season and the minimum concentration was found in pasture soil (6.47 mg/kg) during the pre monsoon.

CO_2 evolution through microbial activity, root respiration and faunal activity in soil is otherwise known as soil respiration and is a good indicator of soil metabolism and fertility. The CO_2 evolution (mg of $CO_2/m^2/h$) ranged from 1384.23 – 1548.76 in agricultural soil, 898.38 – 969.45 in pasture soil, 1938.22 – 2249.68 forest soil and 1211.33 – 1423.45 in garden soil, respectively. The highest CO_2 evolution was observed in forest soil (2249.68 mg of $CO_2/m^2/h$) during the monsoon season and minimum was observed in pasture soil (898.38 mg of $CO_2/m^2/h$) during the pre monsoon season.

Although the value of most of the parameters in the man engineered land is in the lower side as compared to the natural land, the impact on the lands inside the university campus due to the operational activity of the university is insignificant. Timely and regular monitoring of these aspects through various research works need to be conducted to keep an eye on the impact of the institutional activities on the land use systems.

Noise Level Monitoring

The monitoring of noise level was conducted at four stations namely the administrative block, the ladies hostel compound, the boys' hostel compound and the residential block during the day and night time throughout the study period (i.e., post monsoon, pre monsoon and monsoon). The average data recorded along with their respective area code is presented in Table 12. The table clearly suggests that the residential block (C category areas) produced relatively louder sound as compared to the other areas (D category areas) during the day time which may be attributed to the household activities during this hour. The monsoon season however witnessed a greater sound than the other seasons which may have been due to

Table 12. Noise level monitoring (dB) of various sampling stations inside Sambalpur University campus during different seasons of 2016 – 17.

Seasons	Sampling Location	Area Code	Time					
			Day			Night		
			Min	Max	Standard	Min	Max	Standard
Post Monsoon	Administrative Block	D	30	42	50	12	20	40
	Ladies Hostel Compound	D	28	38		18	22	
	Boys Hostel Compound	D	30	36		16	28	
	Residential Block	C	38	47	55	10	12	45
Pre-Monsoon	Administrative Block	D	24	40	50	14	16	40
	Ladies Hostel Compound	D	26	32		10	12	
	Boys Hostel Compound	D	26	34		10	18	
	Residential Block	C	36	46	55	14	20	45
Monsoon	Administrative Block	D	34	44	50	14	20	40
	Ladies Hostel Compound	D	26	36		16	22	
	Boys Hostel Compound	D	32	36		18	22	
	Residential Block	C	40	46	55	18	24	45

relatively high cumulative noise from the activities in the respective areas. When comparison was made among the D category areas, the administrative building produced the highest level of noise in all the seasons, which might be attributed to the rush in office hours in the day time. The noise level at all sampling stations, however, were well within the prescribed standard during all the seasons.

CONCLUSION

The study on the various aspects of environment (air, water, soil and noise) inside the campus of Sambalpur University revealed that the air, water and soil quality as well as noise level are well within the prescribed limit and hence the university can be considered as a green and serene place with ideal environment for higher education as on today. Further, the institutional activities do not have any major impact on the degradation of the environmental quality of the area till today. However, continuous and regular monitoring of the environmental quality in future is important to ensure the development with green practice inside the campus.

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