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Implications of Soil and Water Audit at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India for sustainable development

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Abstract
Soil and water are natural resources of the organization that has to be structured, planned and developed from the point of entry to end users the stakeholders in such a way with contamination free soil and water, sustainable use of land and water resources and suitable measures for their conservation. Soil and water audit is a tool to improve the quality of the land and water resources and for the protection of natural ecosystems to provide a healthy environment to the stakeholders directly and indirectlyfor future prospects. An attempts was made to conduct soil and water audit at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India which revealed that soils were found to be fertile and could be used significantly for plant cultivation in a sustainable manner. Similarly, the result of water quality analysis revealed that water is good in terms of drinking and irrigation without any microbial contamination and possessing rich in nutrients. Analysis of soil profile in terms of testing various soil parameters were carried along with soil fertility analysis in terms of enumerating various beneficial and harmful microorganisms preferred in the campus. Analysis of soil organic matter, ratio of gravel, clay and sand particles, water holding capacity and above the ground biomass were estimated. Detection of Escherichia coli, Coliform bacteria and Faecal Coliform in water samples collected from different places in the campus were done which indicated that these organisms were safe in numbers within the prescribed values.

Keywords: *Soil audit, Water audit, Educational Institutions, Conservation, Eco-friendly environment, Physico-chemical parameters of water, Soil fertility.*

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I. Introduction

Soil and water are inequitable natural resources of India at global level. Soil are naturally occurring loose covering on the earth's surface. Weathering altered the rock particles of soil into mixtures of mineral and organic constituents (Bridges, 1997). Soil is rich in microorganisms and minor pests such as bacteria, fungi, actinomycetes, algae, protozoa and nematodes. The microorganism of the soil helps in enzymatic degradation of organic matter, energy storage and conversion of nutrients in available form in their biomass (Jenkinson and Ladd, 1991). The chemical and physical property of soil makes it a rich medium for the plant growth. Water the other natural resource constituting with 97% of salt water and 3% of fresh water (Alley *et al*., 1999). Water is used in agriculture, industrial, household, recreational and environmental activities. The natural source of fresh water are surface water and ground water. Ground water is used as primary source of domestic drinking water.

Soil and water audit procedures includes the definition, interpretation and methodology on how to conduct soil and water audit at educational institutions and industrial sectors as per the checklist of Environment Management Systems and International Standards on ISO 14001:2015, Jal Jeevan Mission, Swachh Bharath Scheme under Clean India Mission to understand the principles and importance of various audits in the context of the organization and risk assessment at 360˚ views (Gnanamangai *et al*., 2021). Soil and water audit helps the educational institutions/ industries to maintain eco-friendly environment, assures personal hygiene to various stakeholders and supports the nation; on the whole for the noble cause of environmental protection and nature conservation which in turn enhances the quality of life of all living beings (Arora, 2017).

Most of the soil in India are well drained, deep, fairly loamy, slightly acidic to alkaline and lime-free soils and they are ideal for variety of plant cultivation (Arora and Sekhon, 1981). The Indian soils are mainly derived from gneissic rock containing large amount of mica with good behaviour of water holding capacity with abundance of micro and macro elements. Some of the soils are characterized by clay loam type, classified as

latosols with good organic matter contents along with sufficient amount of nitrogen, potassium and phosphorous contents all tea soils are distinctly acidic, rich in nitrogen content and (Mishra, 2020).In order to maintain periodic records on physico-chemical and biological parameters of soil and water in the organization campus, studies were undertaken. Similarly, to maintain contamination free with safe soil and water for the stakeholders, studies were undertaken to assess the environment and personal hygiene in the organization campus. The baseline information to assess threat and risk to the ecosystem with respect to safe soil and water due to Organization development was assessed.

Soil and water audit is a proven technology for providing pure atmosphere without any soil and water pollution and supplying safe drinking water to the stakeholders worldwide since long time. UV light as a biological and chemical technology methods is most effective method to give safe water to the stakeholders which does not create any new chemical by-products, does not change the flavour or odour of the water andalso does not remove any beneficial minerals. Its effectiveness depends upon many factors and it is very important to design the water purifier scientifically so as to deliver the safe & purified water. Water borne disease has been a concern to human being ever since its cause had discovered and the most appropriate treatment process adopted is microbial disinfection. Disinfection is necessary to destroy pathogenic (disease causing) bacteria and other harmful microorganisms that are present in water due to contamination. Over several years, water heating (hot water) and ultraviolet (UV) disinfection as biological technology have been developed into a viable technology for drinking water disinfection. Through all-embracing research and meticulous field experiences, biological disinfection has proven to be safe, reliable, and inexpensive and accepted this as a world ide technology for drinking water disinfection.

II. Materials and Methods

Soil and water audit has been conducted at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India as per the checklist of Nature Science Foundation, Coimbatore, Tamil Nadu, India (www.nsfonline.org.in) through the authenticated professionals for people qualified to investigate and evaluate the campus for validating the best environmental practices (Staniskis and Katiliute, 2016;SCSR, 2018).During the audit, the sources of water and the type of soil within the campus were recorded and samples were collected for the analysis by following the method of AOAC (1990). The operation of the water irrigation system, trip and sprinkler irrigation methods and use of recycled water for irrigation purpose or any other purpose in the campus area were noted. The number of water wells, bore wells and water reservoir facilities in the campus were also noted as per the Audit Manual of Gnanamangai *et al*. (2021).

In order to check the quality of soil at the college campus, the soil samples were collected from different places at a depth of 0–25 cm from the campus. The dry soil samples collected were entirely placed in clean, labelled polyethylene bags and then transported to the laboratory for further analysis after air drying under room temperature. The soil samples were grinded using mortar and pestle to reduce the particle size and then sieved through a 2 mm mesh to obtain acceptable and homogeneous samples. The samples were stored at room temperature until the physico-chemical analysis was performed (Parajuli and Duffy, 2013). Various soil edaphic parameters like soil pH, electrical conductivity (Ec), total organic matter (OM) as carbon content (Walkley and Black, 1984), available nitrogen (AOAC, 1990), available phosphorous (Jackson, 1973), exchangeable potassium (Murphy and Riley, 1962), calcium, magnesium and sodium (Bhargava and Raghupathi, 2001) were estimated as per the protocols mentioned.

Water quality are assessed by measuring the physico-chemical parameters and biological parameters. The water samples are collected from source which include ground water, tap water, RO water and wastewater. The water samples were collected in sterile glass bottles and transported immediately to the laboratory for analysis of physico-chemical and biological parameters by following the method of APHA (1998). Different parameters were examined to find out their suitability for irrigation and even for drinking purposes using Indian Standards as reference (Indian ISI Water, 2002). The physical appearance and colour of the drinking water samples were noted by naked eyes. The taste of drinking water was investigated by sensation perceived in the mouth on contact. Similarly, the odour of the water was sniffed as described by Arceivala (1998).

The pH and conductivity of drinking water samples were measured by dipping the pH electrodes into the water samples and readings were noted by using a pH meter (Systronics, AL113) and digital conductivity meter (Elico, ADI51L); respectively. Drinking water samples were thoroughly shaken and wait until air bubbles disappeared. 10 ml of the samples were poured into the turbidity meter cuvette and read the turbidity using a digital nephlometric turbidity meter (Elico, Tu1020). Hundred ml of the drinking water samples were filtered through a glass fibre filter paper (200 µm size). The filtrate was evaporated on a tared porecelain dish. The porcelain dish was preheated at 105^0 C and then at 550^0 C, cooled and brought to constant weight. The dish was kept at 105^0 C for about 1 hr, cooled and weighed subsequently. The increase in weight denoted the total dissolved solids content in the water samples. Following the method of APHA(1998) the chemical constituent of the sample including Nitrate, chloride, sulphate, fluoride and iron were detected spectrophotometerically.

Assessment of microbial contamination in the water and soil samples collected from the college campus was carried out. Indicative bacterial species such as coliform bacteria, faecal coliform and *Escherichia coli* present in water samples collected from different sources was analysed by following three methods such as presumptive, confirmed and completed tests. The sterile Petri plates containing nutrient agar (NA), potato dextrose agar (PDA) and casein nitrate agar (CAN) Similarly, for the enumeration of *E. coli* were taken for the enumeration of bacteria, fungi and actinomycetes; respectively in air to assess the number aero-flora (IMTECH, 1998). These plates were exposed for 2-3 minutes at specific places where the number of microorganisms as microflora in the air were to be enumerated. The exposed Petri plates were incubated under room temperature for 24-96 hours. Similarly, one ml of water samples was transferred to the petriplates containing the basal medium and then incubated under the controlled environments (Cappucino and Sherman, 1992).

The number of bacterial colonies grown in the Petri plates containing nutrient agar medium within 24-48 hrs of incubation period were counted using a Colony counter. In the case of fungal growth, the Petri plates containing potato dextrose agar medium were observed after 72-96 hrs of incubation. The colony of actinomycetes were recorded in between the incubation period of 48-72 hrs. The bacterial colonies exhibited different shape, size, colour and texture on morphology. Fungal colonies were identified based on visual characteristics such as colony morphology, elevation, colony margin, aerial mycelium and colony colour. Actinomycetes showed a good sporulation with compact and dense, chalk-like dry colonies with powdery mass, different colour variations from pale pink to white colour on the Petri plates and shown a branched filamentous mycelium in their cell / filament morphology similar to fungal characters (Holt, 1989; IMTECH, 1998).

III. Results and Discussion

Soil and water audit may be beneficial to the campus in improving the activities of sustainable land and water which in turn useful to save the planet for future generation. It is a kind of professional care and a simple indigenized system about the environment monitoring in terms quality enhancement of soil and water which is a duty of each and every individual who are the part of economical, financial, social, and environmental factors. It is necessary to conduct soil and water audit frequently at least once in three years in campus because students and staff members should aware of the soil and water audit and its beneficial effects in order to save planet by means of 'Jal Jeevan mission' and "Sustainable Land Management" which in turn support the institution to set environmental models ('icon') for the community. According to Gnanamangai et al. (2021), soil and water audit is a professional and useful measure for an Organization to determine how and where they are retaining the campus eco-friendly manner. It provides an opportunity to the stakeholders for the development of ownership, personal and social responsibility.

The pH is an operationalwater quality parameter and is important when disinfecting water with chlorine. EC is unusually high levels may suggest chemical contamination. Turbidity could be an indication of surface runoff and may interfere with water treatment. Bacteria and viruses can attach to suspended particles and cause health risks. High turbidity decreases water acceptability. Fluoride is a naturally occurring form of the element fluorine, which is sometimes found in groundwater at levels that exceed safe levels. Too much fluoride can cause pitting and staining of tooth enamel. Long term exposure to high levels could lead to bone issues in adults. Nitrate and nitrite could occur due to the fertilisation of nearby farm fields or sanitation facilities located too close to the well. In most cases, these compounds aren't a serious health risk. They are harmful to infants, however, causing blue baby syndrome, which can be fatal. Chlorine 5mg/L is the health based guideline. Chlorine is often used for water treatment. The physico-chemical constituents of borewell water samples of the campus including pH, conductivity, colour and odour, chloride sulphate fluoride and iron below the maximum limit of Indian standards of Drinking water quality. Whereas total dissolved solids, hardness, Turbidity and alkalinity were observed to be above the maximum limit of Indian standards of drinking water quality. Hence the direct consumption of borewell water is not recommended for drinking purposes. The high value of total dissolved solids, hardness, turbidity and alkalinity of borewell water is reduced on adopting reverse osmosis technology (Gnanamangai et al., 2022). The results of physico-chemical constituents of water samples collected from the college campus was given in the Table 1. The results indicated that all the parameters were found to be within the limit of Indian standards of drinking water quality. However, the borewell water were being treated by RO system for drinking purposes to the stakeholders every day in the college.

Soil physico-chemical properties influence the behaviour of soil and hence, knowledge of soil property is important. Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Soil properties that are sensitive to changes can be used as indicators to improve soil quality (Vinothkumar et al., 2022). Analysis of soil is carried out for the studies of various parameters like total Organic Carbon, Available Nitrogen (N), Phosphorus (P_2O_5) and Potassium [K_2O], pH, Electrical conductivity, soil texture, bulk density, chloride, fluoride and % moisture content (Table 2). The fertility of the soil depends on the concentration of N, P, K, organic and inorganic materials, conductivity. The physico-chemical properties such as moisture content, Nitrogen, phosphorus and organic matter required for the

growth of plant. Potassium is used for flowering purpose, it is also required for building of protein, photosynthesis, fruit quality and reduction of diseases and phosphate is used for growth of roots in plants. The soil profile and soil edaphic parameters of the campus observed to be low in the essential nutrients which are needed for the plant growth. The soil fertility has to be enhanced by adapting vermicomposting and proper irrigation facility (Arora and Sekhon, 1981).

Water is considered a vehicle for the propagation and dissemination of human associated bacteria. Safe drinking water is a fundamental human right and if contaminated with opportunistic pathogenic environmental bacteria, it may have health implications for consumers (Rajalakshmi et al., 2022). Human health should therefore be protected by preventing microbial contamination of water that is intended for consumption. These unprotected water sources can be contaminated with microbes through rainfall run-off and agricultural inputs, mixing with sewage effluents and faeces from wild life, which render them unacceptable for human consumption. They are some of the Faecal coliforms, *Aeromonas* and *Pseudomonas*, are used as indicators of faecal contamination in water and the presence of these pathogens may have severe health implications on consumers especially those that are immunocompromised (George *et al*., 2014). Presence of Faecal coliforms in the water samples can be measured by MPN index. MPN index can be performed by conducting multiple tube fermentation test.

The water samples of Nehru college campus were measured by taking five numbers of 10ml in 10mldouble strength MacConkey broth, five numbers of 1ml of water in 5ml of single strength MacConkey broth and five numbers of 0.1ml of water in 5 ml of single strength MacConkey broth. From the result it is confirmed that water sample I is showed the presence of Faecal coliforms, whereas water sample II and III showed the absence of Faecal coliforms. Determination of water pollution indicative bacteria was carried out by following serial dilution techniques and most probable number (MPN) method (Cappuccino and Sherman, 1992; Dubey and Maheshwari, 2002). All the microbial analysis works were carried out under aseptic condition. From each serial dilution, 1ml of the samples was taken and transferred to test tubes containing 5ml Lauryl trptose broth. The tubes were then incubated at 37^{o}C for 24-48 hrs. The tubes showing colour change from purple/violet to yellow were taken as positive. The number of positive tubes at each dilution was used with the MPN tables to give number of bacteria present in the original sample. The positive tubes were streaked onto Eosin Blue Agar plates, using a sterile loop and incubated at 37^{o}C for 24 hours. The isolated colonies were subjected to observe green metallic in reflected light with dark purple centers by transmitted light. Identification of water pollution indicative bacteria by Presumptive test was carried out by taking a series of test tubes containing double strength lactose broth in which different concentration of water samples was dispensed. All the tubes were incubated at 37°C for 24 hours for gas production. Production of gas was hereby confirmed the presence of coliforms in the water sample. Characterization and morphological identification of water pollution indicative bacteria were made by referring "Bergey's Manual of Determinative Bacteriology" (William and Wilkins, 1994).

Soil microorganisms can be grouped into bacteria, actinomycetes, fungi, algae, protozoa, and nematodes. They are responsible for the majority of enzymatic processes in soil and store energy and nutrients in their biomass (Jenkinson and Ladd, 1981). Soil microorganisms are responsible of soil fertility and quality are strongly affected both by the type of soil management and irrigation. Chemical indicators can be measured by monitoring soil pH, salinity, organic matter content, cation and anion exchange capacity, nutrient cycling, and the presence of toxic or radioactive elements, while biological indicators may include measures of the presence of macro- and microorganisms, as well as their activities and by-products (Rajalakshmi et al., 2021). During the audit in the college campus the soil and water were analysed for the presence of pathogenic microorganism including bacteria, fungi and actinomycetes (Fig. 1). It is found that the number of microbial colonies is very less which in turn proved the purity of soil and water available in the college campus (Table 3).

After the establishment of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India in the past few decades, it has made significant progressive contributions with respect to not only in teaching and learning, research and consultancy, innovation and technology transfer, community service and value educationto rural, tribal and urban people across but also providing an ecofriendly atmosphere to the stakeholders.The college campus is maintaining neat and clean soil and water resources by means of proper checking of their physico-chemical and biological parameters periodically. The installation of a rainwater harvesting system, percolation ponds and drip irrigation system to conserve rainwater and ground water status are noteworthy in the campus in a sustainable manner.

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Table 1. Analysis of Physico-chemical parameters of water samples collected at different sources of the Nehru Arts and Science College, Coimbatore, Tamil Nadu, India.

S.No	Parameters	Borewell Water**	ROwater**	Recycling Water**	Standard (IS 10500:2012)
1.	pH	7.15	6.23	7.57	6.5 to 8.5
2.	Conductivity (micromhos/cm)	1655.03	1274.25	1358.33	2000
3.	Colour (Hazen unit)	Colourless	Colourless	Colourless	Colourless
4.	Odour	Agreeable	Agreeable	Agreeable	Agreeable
5.	Taste	Tasteless	Tasteless	Tasteless	Tasteless
6.	Total dissolved Solids*	756.53	626.27	647.45	500
7.	Hardness*	213.60	255.55	213.57	300
8.	BOD*	43.57	47.27	40.05	50
9.	COD*	24.93	26.67	28.17	50
10.	Dissolved oxygen*	137.43	144.17	140.63	150
11.	Dissolved CO_2*	122.55	117.00	134.63	150
12.	Turbidity (NTU)	0.15	0.13	0.15	1.0
13.	Alkalinity*	157.53	185.37	185.47	200

14.	Salinity*	144.63	152.17	157.25	200
15.	Acidity*	167.25	172.40	177.77	200
16.	Nitrate*	8.83	8.65	8.13	10
17.	Chloride*	235.33	244.75	229.43	250
18.	Sulphate*	188.17	189.25	189.60	200
19.	Fluoride*	0.85	0.53	0.63	1.0
20.	Iron*	0.71	0.55	0.65	1.0

* mg/L
** Average of three replicates

Table 2. Soil profile and edaphic parameters of the Nehru Arts and Science College, Coimbatore, Tamil Nadu, India.

S.No	Description	Results / Observations*
Physical parameters of soils		
1.	pH	8.53
2.	Electrical Conductivity	0.85dSm^{-1}
3.	Water holding capacity	75.53
4.	Sand: Gravel: Clay Ratio	25:20:55
5.	Moisture Content	80.85 %
6.	Dry matter Content	35.53 %
Macro Nutrients estimations in soils		
7.	Total Organic carbon	8.37 %
8.	Available Nitrogen	2.30 %
9.	Exchangeable Potassium	28.53 mg/kg
10.	Available Phosphorous	35.65mg/kg
Micro Nutrients estimations in soils		
11.	Exchangeable Calcium	262.33 mg/kg
12.	Exchangeable Magnesium	126.37 mg/kg
13.	Exchangeable Sodium	32.65 mg/kg
14.	Manganese	30.07 mg/kg
15.	Exchangeable Zinc	22.00 mg/kg
16.	Exchangeable Ferric	27.83mg/kg

* Average of three replicates

Table 3. Number of Microbial colonies in soil and water samples at different locations of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India.

S.No.	Name of the Place	Number of Microbial colonies (cfu) *			Total Colonies
		Bacterial colonies	Fungal Colonies	Actinomycete Colonies	
1.	Water Sample I (Tap water)	5.3	3.7	2.1	11.1
2.	Water Sample II (Drinking water)	1.7	1.3	1.0	4.0
3.	Water Sample III (Open well water)	8.5	7.3	5.5	21.3
4.	Soil Sample I (Open land)	12.5	9.3	7.7	29.5
5.	Soil Sample II (Gardening)	12.0	10.3	9.7	32.0
6.	Soil Sample III (Vegetation)	15.5	13.5	12.3	41.3

* Average of three replicates

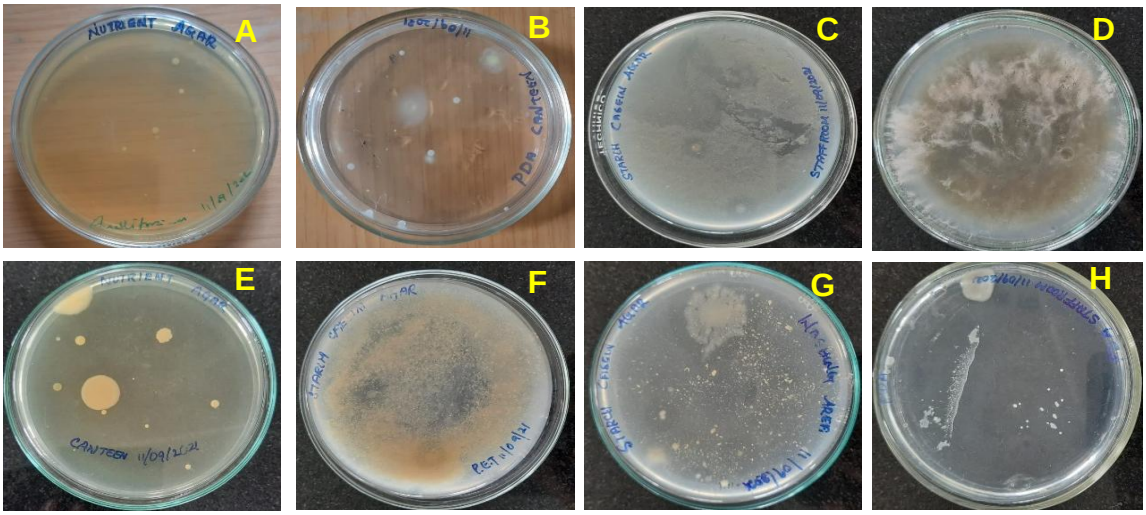

Fig. 1. Microbial colonies in Potato Dextrose Agar medium in different places of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India.

[A. Principal's Cabin, B. Staff Room, C. Laboratory, D. Seminar hall, E. Library, F. Canteen, G. Class Room, H. Common Room]