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Research Article

A CASE STUDY ON WATER MANAGEMENT STRATEGIES DOCUMENTED UNDER ENVIRONMENTAL AUDIT AT NEHRU ARTS AND SCIENCE COLLEGE, COIMBATORE, TAMIL NADU, INDIA

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A B S T R A C T

Assessing water management policy and water audit are an integral part of Environmental Audit (EA) and is a prerequisite for National Assessment Accreditation Council (NAAC) while reviewing an educational institution. Water audit recognized as onsite inspection within the campus and its movement/cycle to identify possible threat to inhabitants and the environment. In accordance with the environmental audit and water management policy of an organization, water audit is performed in the educational institution with regard to water source, supply, utility and conservation measures besides sanitation and hygiene. The present case study is a document relates with water management policy under Environmental Audit carried out at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India.

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INTRODUCTION

Environment audit is quantitative and qualitative data totrackair, soil, water and environment quality and to gain actionable insights to improve the operational performance in the atmosphere. Environmental auditisgenerally used to observe, measure and control to reduce environmental pollution in order to protect the clean and green environment of an Organization. It offers a healthier environment which makes ease for the stakeholders and all living organisms of the ecosystem. Healthier environment assures a progressive success of an organization in terms of safeguarding the upcoming generations and by protecting the natural resources. In this regard, the management of educational organization should concentrate their efforts to improve the environmental performance and to minimize the environmental pollution. Purpose of environmental audit is to recognize, enumerate, describe and organize the framework of sustenance of environment incompliance with the appropriate rules and regulations. By and large, primary objective of environment audit confined to protecting the healthier environmental and minimize the threats posed by human, however, it also focus on create consciousness among the stakeholders about clean environment and conservation of the same, minimize the environmental pollution by means of developing sanitation and hygiene, water conservation, waste management and green campus and environmental policies.

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Without water no organism thrive on the earth; it is fundamental requirement for everything. It has been reported that only 3% of fresh water available on earth; out of which two-third portion is locked as ice glaciers/perpetual snow. Out of remaining one per cent fresh water resources, one-fifth portion is available at remote areas while seasonal rainfall and floods cannot easily be used. It may be noted that <1.0% freshwater is being exploited by mankind for their demand, particularly for sanitation, drinking, manufacture, agricultural requirements, etc. In ancient days, water is available abundantly and at present it becomes as a more valuable commodity due to expected seasonal changes and ever increasing population. In order to administering the supply and demand of available freshwater, it is necessary to follow water management practices under set policies and regulations to ensure that drinking water is available to all, at present and for future generation.

Educational institutions, research organizations, industries, factories, commercial complexes, government and non-governmental agencies consumes water for different purposes. Its needful utilization, supply and disposal are directly linked to wastewater management which directly influences flora and fauna of the ecosystem. At this juncture, regular monitoring the water requirement and utilization of above said organization is very essential. Keeping in this mind, water management audit was executed at Nehru Arts and Science Collegeas an integral part of environmental audit. The present study highlights water management policy, norms related with

water management audit and practices adopted in the College campus premises.

RESEARCH METHODOLOGY

Study area

Nehru Arts and Science College, Coimbatore, Tamil Nadu, India is situated at an altitude of 415 m above mean sea level, 76°58'21" E of longitude and 11°1'6" N latitude with a land cover of35 acres. Fairly warm/dry condition prevails through most parts of the year. With the onset of winters in North and South parts of India, temperatures marginally lowered down between December and January (~22°C). During the summer months, the mercury level rises as high as 42°C. The months between June and November accompanied by rains, however the area does not receive abundant rainfall; annual rainfall lingers around 85 cm.

Survey components of water management audit

Environment audit conducted by a team of auditors belonging to Nature Science Foundation (NSF), Coimbatore, Tamil Nadu. It is an ISO 9001:2015 & 14001:2015 certified and Ministry of MSME registered organisation. Survey covers both qualitative and quantitative measures including physical observation, particularly the targets achieved by the implementing agency against their objectives and/or requirements. Components of water management policy includes water conservation measures, rainwater harvesting program, wastewater recycling procedures and sanitation and hygiene facilities besides water consumption and its resources. Drinking water resources including bore-, open-wells, ponds and Municipal or Corporation water facility available at the stakeholders are investigated for their physical appearance and overall ambience. Under rainwater harvesting program, establishment, implementation and maintenance of the facility are examined on the spot. Under water conservation strategy, monitoring the overhead tanks cleanliness, recycling of treated water, leakages in the supply system, drip/sprinkler irrigation system for watering the vegetation was carried out. It is regardless to mention that water taps, plumbing adequacy and their efficiency and adequate drinking water facility were also considered in water management audit. Since the qualitative and quantitative measurements are serves a tool in the environment sustainable development in any ecosystem, above said parameters were given due importance in water management audit (Gnanamangai *et al*., 2021).The survey site includes the laboratories, gardens, canteens, hostels meant for scholars, wash rooms, auditorium, class rooms and staff rooms besides the guest rooms where the members of auditing team observed the facilities and also had discussion with the concerned staff/officers. Number of open wells, bore wells and water reservoir facilities in the campus were recorded as per the audit manual of Gnanamangai *et al*. (2021).

Physico-chemical parameters of tap water, reverse osmosis (RO) water and recycled water such as appearance, colour, odour, taste, pH, conductivity, turbidity, total dissolved solids, biological demand (BOD), chemical oxygen demand (COD), dissolved oxygen, dissolved carbon-di-oxide, alkalinity, salinity, turbidity, hardness, nitrate, chloride, sulphate, fluoride, iron, sodium, magnesium, manganese and zinc and were estimated according to the suitable methods (AOAC, 1990; APHA, 1995; Arceivala, 1998). 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, conductivity and turbidity of water samples were measured by dipping the pH electrodes into the water samples and readings were noted by using a pH meter (Systronics, AL113), digital conductivity meter (Elico, ADI51L) and nephlometric turbidity meter (Elico, Tu1020); respectively. The amount of various micro and macro elements present in the water samples was calculated by using a standard graph prepared from the respective standard chemicals for comparison purpose against a blank solution (distilled water).

RESULTS AND DISCUSSION

It is essential that any environmentally responsible institution should examine its water use practices. Qualitative/quantitative audit revealed the Nehru Arts and Science College adopted an internal water management audit procedures (as an integral part of environmental audit) in conformity with environmental audit rules. Auditor concerned investigated the relevant methods that can be implemented to achieve balance between water demand and supply. Conservation and maintenance of water facilities were appropriately assigned to the staff/officer concerned and they are concerned with health and hygiene of the end-users.

Resources

The water supply network of Nehru Arts and Science College campus is very complex. Many of the major water lines running in the campus were laid during the establishment of the campus. Available water, both supplied by Municipal/Corporation and from bore wells, is used for different purpose in the campus like residential, hostel, academic and hospitality uses, laboratory uses, used for landscaping/gardening, etc. Qualitative and quantitative measurement indicated that the Nehru Arts and Science Collegecampus found to be self-sufficient in meeting the demand of water. Qualitative measurement also indicated that within the campus, drinking water facility is available according to the requirement/needs, adequately.

The results on physicochemical properties of water samples estimation showed that there was a minor difference in appearance, colour (Hazen unit), odour, taste, turbidity, pH, conductivity, total dissolved solids, hardness, turbidity (NTU), alkalinity, salinity, BOD, COD, dissolved oxygen, dissolved carbo dioxide, chloride, sulphate, fluoride and iron contents of samples collected from Nehru Arts and Science College campus (Table 1). The minor differences between samples are due to water sample collection sites and treatment process (Anilkumar *et al*., 2012). All test parameters were found to be within the norms as per the water quality parameters of IS:10500, 2021 standards.

Water consumption

Since several variables are influenced water consumption by various stakeholders of an organization, it is hard enough to precisely assess the water quantity demanded by the public. However, it has been estimated that per capita requirement of water at hostels and canteen ranged from 65 to 300 litres with a mean of 160 litres which accounts 35% of overall water

consumption at Nehru Arts and Science College campus. Commercial demand of water at various laboratories ranged between 45 and 450 litres per day with an average of 135 litres (30%). Irrigation of the vegetation and transport wash (public uses and fire demand, if any) required 20 – 90 litres/day was estimated with a demand of 90 litres per day which accounts 10% of total consumption while losses through leakage, etc., and routine sanitation requirement accounts 20% of total which ranged between 45 and 150 litres per day with a mean of 62 litres of water. Only 5% of water really consumed for drinking and day-to-day routine (domestic needs). Observation recorded at Nehru Arts and Science College campus comparable with the earlier report (Mahish, 2017).

One of the report defined the benchmark for the water usage, where water use does not exceed approximately 350-450 litres (90 -120 gallons) per scaled campus unit per day for residential and non-residential campus facilities (Pradiprao and Attar, 2018). However, in their concluding remarks they indicated that "No one has done quantification of green audit", and they also indicated the importance of developing rating system to derive a proper estimation of all areas of green audit. It has been reported that the educational institutions without boarding facilities using 45 lit/day (domestic use + flushing) and 135 lit/day with boarding facilities. Water consumption per user in non-residential buildings is still a very complicated task for engineers/designers in the process of analysing demand and water management (Rajalakshmi *et al*., 2021).

Wastewater recycling

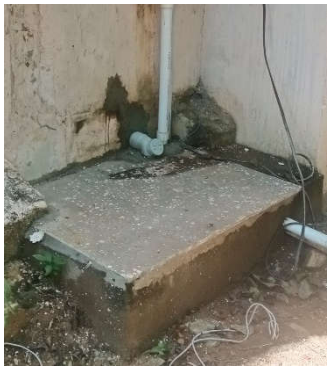
Wastewater recyclers are important features in any Organization or Industry. Once for all the implementation should follow the proper guidelines for wastewater treatment system discharge standards as per Central Pollution Control Board (CPCB). The main feature of these discharge standards is the treated water should not be harmful to the biodiversity, resources and the environment. If an industry or Organization has the waste water treatment plan, proper records on the analysis of water input and out put parameters including the running time of the wastewater treatment plant; its operation cost, its maintenance and the reuse records of the treated water should be well accounted. A typical wastewater treatment system should be based on the waste characterization and the treatment of wastes which can be modified so as to fit into the motto of treating the wastewater which in turn to release of safe with potable water.

Nehru Arts and Science College is taking enough attempt to manage wastewaters that are coming out from various Department laboratories, hostels and canteens. The wastewater treatment plants were established and maintained adequately; recycled water used properly. The campus has a very good wastewater treatment facility (Fig. 1) covering primary, secondary and tertiary water treatments for elimination of excess phosphorus, potassium, zinc, chromium and nitrogen contents along with harmful pathogens and the degradation of inorganic wastes. Wastewaters are treated with both chemical and biological treatment methods using activated-sludge, UV light and chlorination. There is a proper connectivity and channels for the discharge of wastewaters from various departments, canteens, cafeteria and hostels to wastewater treatment plants. The wastewaters are purified considerably and reused for gardening as water reclamation. Small scale level drip irrigation facility established in the campus, however, it may be extended further in order to effective utilisation of recycled water. In addition, recycled water can be used in the flushing the toilets and vehicle washings, etc.

Water shortage has become an increasingly difficult problem to manage. More than 40% of the world's population live in a region where the demand for water exceeds its supply. The imbalance between supply and demand, along with persisting issues such as climate change and population growth, has made water reuse a necessary method for conserving water (Fatta-Kassinos *et al*., 2016). There are a variety of methods used in the treatment of wastewater to ensure that it is safe to use for irrigation of food crops and/or drinking water.

Hygiene

Quality of water plays an important role in water consumption rate. If water is aesthetically and medically safe, the consumption will increase as people will not resort to private wells, etc. There is a Reverse Osmosis (RO) water unit to get RO water. The RO treated water is periodically tested for the physico-chemical properties for which Registers containing data relevant to water analysis are being maintained. There is aperiodical test to check the physico-chemical properties of waste waters such as pH, biological oxygen demand, chemical oxygen demand, dissolved oxygen and carbon-di- oxide and total soluble solids before reuse for gardening. The quality of water is fit for drinking purpose. Drinking water quality underlies various parameters, however, in general, it should guarantee potable, wholesome and palatable water (Mutharasi *et al*., 2016). As mentioned earlier, physical appearance and physic-chemical properties of the water are maintained in College campus. Appropriate sanitation measures in water supply system found to be adequate and maintained efficiently. Physical and chemical parameters of tap water, RO water and recycled wastewater are presented in Table 1.



Rainwater harvesting system and conservation measures

Water conservation strategies broadly rely on a) adequacy of water, b) elaborate plumbing facilities with adequate, suitable water taps and sanitary fixtures, c) establishing water use efficient toilets, d) well organized water usage, e) dedicated staff for water management including inspection and f) periodic service/repairs/corrective measure of leaks in taps and pipes (Technical Report, 2021). Rain water harvesting programme is concerned with establishment of implements for rainwater harvesting within the campus by creating rainwater harvesting pits. A small squire shaped rainwater harvesting pits containing gravels and sand constructed near the buildings and well-connected with pipes from the roof to pits. Within the campus, rainwater harvesting structures and recharge well have been commissioned at different locations. Under water management strategy, water conservation mechanisms should

be efficiently adopted, wherein sprinkler/drip irrigation system may be installed within the campus for irrigating the plants. In recent days, water crisis is very sensitive issue in the world. As mentioned earlier, the institution has relatively lesser concrete area (built area + floor area) which substantially allow to percolate the rainwater to maintain the underground water level. It may be noted that rainwater collection drains and recharge pits are to be well designed for highest hourly peak follow in accordance with the site topography. Though, rainwater harvesting system and adequate plumping works were established and maintained properly in the College campus, the study area is fast developing commercial and residential areas where the extraction of ground water is expected to increase in future. Hence, the proper distribution network, rainwater harvesting and storm water drains has been specially designed in the campus. Conservation measures includes groundwater recharge and maintenance of water balance, reuse and recharge structures and preservation of existing water bodies and adopting water management protocols.

Table 1 Physical and chemical parameters of water collected at different sources at Nehru Arts and Science College

Parameters	Tap water	RO water	Recycled wastewater
pH	7.8	7.2	7.8
Conductivity(micromhos/cm)	1919	1948	1943
Colour(Hazen unit)	1	2	1
Odour	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Salty	Agreeable	Agreeable
Total dissolved Solids*	2144	2363	3257
Hardness*	675.8	780.6	788.6
BOD*	1.57	1.87	1.64
COD*	11.6	12.4	11.9
Dissolved oxygen*	7.34	7.14	7.23
Dissolved CO_2*	1.64	1.57	1.72
Turbidity (NTU)	3.87	3.45	4.67
Alkalinity*	284.4	274.4	287.6
Salinity*	2.94	3.14	3.78
Nitrate*	26.4	27.7	28.9
Chloride*	374.5	407.5	418.5
Sulphate*	23.8	24.4	24.5
Fluoride*	0.94	0.88	0.83
Iron*	0.76	0.73	0.84

* mg/l

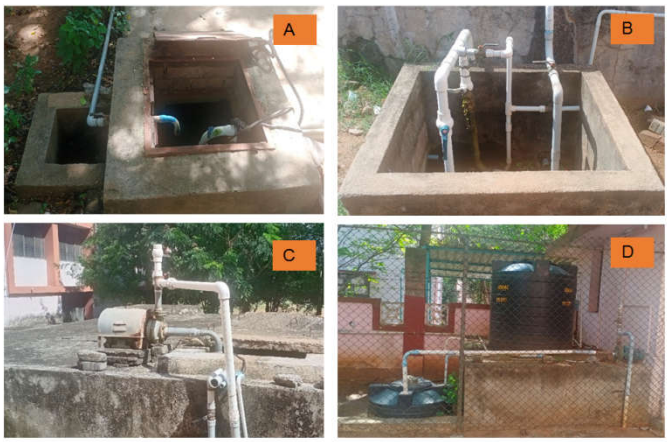


Fig 1 Wastewater recycling facility installed at Nehru Arts and Science College campus
[A. Wastewater Collection Point, B. Water Supply Connections, C. Wastewaters Recycling Process, D. Purified Water Storage Tank]

Leakages

Leakage accounts a largest share of wastage of available water resource as well as unauthorized water use. Each source meter required to be tested for its accuracy, either by reviewing available meter test results or retesting the meter. System valves mandatorily reviewed periodically to detect malfunction (Mohanraj *et al*., 2021). For instance, altitude control valves on storage tanks might be damaged or installed improperly, allowing the tank to overflow. These valves need periodic inspection, more so when there is observed leakage or over flow. Pressure relief valves set too low might cause spill when pressures reach the high range. These pressure relief valves need to be calibrated accordingly. When leakage problems are discovered during routine inspections, possible water losses need to be estimated and corrective action can be taken up immediately. A small drip from a leaky tap can waste more than 180 litters of water a day that is a lot of water to waste - enough to flush the toilet eight times! Aquifer depletion and water contamination are taking place at unprecedented rates in a sustainable manner (Johnson *et al*., 2010).

Water management practices followed by Nehru Arts and Science College

It is observed that the Organization is created massive facilities for wastewater treatment facility to purify wastewaters effectively without harming the environment. There is a reverse osmosis (RO) water unit to produce RO water which is periodically tested for the physico-chemical properties. A well-established rainwater harvesting system to recharge ground water status by collecting rain waters from the campus coinciding with the contour of the terrain and natural drains. On the whole, at Nehru Arts and Science College Management adopted water management policy in accordance with legislative compliances to minimise waste generation, recycling of wastewater and periodical documentation their physic-chemical properties and conducing outreach programmes to the nearby rural, urban community with respect to water consumption and its conservation strategies. More importantly, monitoring and taking corrective measures with respect to water management by enthusiastic designated staff has to be taken care off (Technical Report, 2022).

CONCLUSIONS

Qualitative measurement also indicated that within the campus, drinking water facility is available according to the requirement/self-sufficient; wastewater treatment plants, rainwater harvesting system and adequate plumping works were established and maintained properly. Sign boards indicating "Don't waste water", "Conserve water for future", etc., and automated technology to minimize the consumption of water are to be established to improve the water conservation strategies. Finally, Nehru Arts and Science College, Coimbatore, Tamil Nadu, India is a well-established Institute in India in terms of academic activities and as far as environmental protection initiatives adopted by the College are substantial by means of creating wastewater treatment, sanitation and rainwater harvesting system without harming the environment.

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