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ENVIROMENTAL AUDIT AND SURVEY AT AN ENGINEERING INDUSTRY

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ABSTRACT

A comprehensive survey and audit was carried out at an Engineering industry in Karnataka, India. The base line study was conducted during Pre Monsoon season beginning from the month of March 2011 for air, water, soil, noise, biological and socio-economic components of environment; identification, prediction and evaluation of impacts and delineation of environmental management plan for mitigation of adverse impacts. The environmental status was assessed based on primary and secondary data collected through on-site field observations. Survey was used for the audit of compliance with National Laws and Regulations, Health and Safety, Pollution Prevention Systems. Site survey for representative sampling was carried out. Impacts were also evaluated qualitatively using engineering judgment and best management practices.

INTRODUCTION

Maintaining a clean environment with regard to water, air and soil around any Industrial complex or supporting facilities is prime responsibility of Industries, which is not only required to meet various legislations in force but also as responsibility towards health of employees and surrounding public. With this objective in mind a detailed Environmental Survey and Audit was carried out in a large Engineering industry in Karnataka, India.

The study (Audit and Survey) was carried out keeping following objectives:

a. Ambient air monitoring at representative location in and outside the industries premises for all necessary parameters as per revised and latest Norms of Ministry of Environment and forests
b. Stack monitoring on all the existing stacks in the for all parameters as specified in the latest consent
c. The noise monitoring
d. Indoor air monitoring at all representative sites in the industry for physico- chemical and biological parameters
e. Drinking water quality check-up at representative sites and points for all parameters as per IS standards including heavy metals, all toxic compounds and comprehensive biological and /microbiological study
f. Quantification of all wastewater and characteriza-

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tion for all necessary parameters relevant and legally binding to the type of operation, flow measurement, composite sample analysis for all parameters

g. Detailed study of all existing wastewater treatment plants (sewage and industrial) for their performance by repeated sampling for all necessary parameters and a complete review of state of treatment plants for civil, mechanical and electrical compounds.

h. Detailed study of all treated wastewaters (sewage and industrial) disposal practices and their impact on environment. Detailed study of soils where treated wastewater is used for gardening

i. Detailed study of all sludge disposal method and their impact on local environment

j. Complete water and wastewater audit by detailed study of water consumption, waste generation patterns, treatment, reuse etc

k. Detailed study of solid waste generation (hazardous and non- hazardous) from the concerned industry, quantification and characterization

l. Complete study of disposal /treatment practices for all solid wastes

m. Suggestions for future environmental monitoring schedules for legal compliance, water consumption minimization/reuse opportunities, waste minimization (solids and liquids), steps necessary for improving the performance of existing air pollution control system, wastewater treatment and solids disposal, protection of indoor environment and ambient air, water and land environment, capacity building initiates needed for long term environment protection and need improving/ creating environmental infrastructure including manpower

METHODOLOGY

Attributes of the physical environment like air, water, soil, air microflora and noise quality in the surrounding area were assessed, primarily through field studies, and by undertaking monitoring and analysis of samples collected from the field.

Various methods have been used for environmental auditing namely site survey, report collection and interviews for the audit of the management system. Site survey for representative sampling was carried out. The surveys for Rain Water Harvesting systems, Biogas plant, Vermicomposting unit, water leakage, Mold infection in the engineering indusrtry were conducted on 21st and 22nd March, 2011. The air sampling including ambient and stack monitoring (DG set) were carried out on 23rd March, 2011. The collection of water samples and survey for Municipal Water, STPs and Noise pollution were carried out on 23rd March, 2011. The collected water samples for biological parameters were maintained at 4°C during transportation as per standard method and deposited for further analysis in laboratory. The soil samples, air micro flora collection (on selective nutrient media) and solid waste from kitchen were completed on 23rd March, 2011. The soil samples were collected from four different locations for physico-chemical parameters. The collected air microflora on selective media in Petri plates were maintained at 4°C during transportation as per standard method and incubated at the respective temperature in the laboratory. All the abovementioned sampling (environmental parameters) have been used for identification, prediction and evaluation of significant impacts.

Air environment

The existing quality of the air environment serves as an index for assessing the pollution load and the assimilative capacity of any region. Ambient air quality data was collected for summer season (March, 2011) to understand the air quality in the region and to assess the impacts on air environment. The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality-monitoring network. The design of monitoring network in the air quality surveillance program has been based on the following considerations:

i. Topography of the study area.
ii. Representatives of regional background air quality for obtaining baseline status.
iii. Representatives of likely impact areas.

Ambient air quality in study area

An assessment of air quality was undertaken to establish the status of exposure of the receptors. This assessment was accomplished by examining sources of air emissions within the study area, and by conducting a site–specific background–sampling program.

The three sampling regions were selected:

1. Near Main gate of the industry
2. Production area for Indoor air sampling and

Ambient and Indoor air sampling were carried out with high volume sampler model (Envirotech, APM 460 BL) and Indoor sampler model (APM 821) respectively. Stack monitoring of D.G. set (625 KVA) was recorded with analyzer model Vayubodhan (VSS-1). In this manner, all pollutants were collected at each of

the three locations. Analysis of pollutants was done as per standard IS codes. Monitoring results (observed levels and ranges) are presented in Table 1,2,3. Sources of air pollution affecting the region currently are vehicular traffic and dust arising from constructions and roads. The air environment around site is free from any significant pollution source. Therefore, ambient air quality is quite good in and around the area. SPM and RSPM levels were observed to be normal. All the other parameters were observed to be well within the prescribed standards.

Study of microbial contamination in the indoor air

Monitoring and Enumeration of Air Micro-Flora

Sampling and Analysis

In the present study, outdoor and indoor airborne microflora (bacteria) at different locations was investigated during summer season on 23rd March, 2011. Temperature and relative humidity (RH) were recorded over the sampling period. The bacteria were collected by impaction onto an agar medium, for 2 to 8 minutes, placing above the surface, to simulate the human breathing zone. Before or after each sampling, surface was disinfected with a 70% ethyl alcohol solution. Sampling was carried out for all the sampling points during daylight hours 09.00 and 17.00 hrs.

Observations

The following salient observations were made by our team:

a. Indoor humidity (34 to 46%)
b. Leaky roof, venting lacking in kitchen etc.

Culture Media

General detection and enumeration media are normally used in the collection of fungi, bacteria, and thermophilic Actinomycetes. Plates were replicated on selective media for identification after the organisms have been collected. The following nutrients media were used for the micro-flora sampling:

1. Fungi
Malt extract agar (MEA) media was used for the collection and enumeration of fungi

2. Bacteria
Tryptic soy agar (TSA)/ nutrient agar (NA) media was used for the collection and enumeration of bacteria.

3. Thermophilic

Standard plate count agar [SPCA]) media was used for the collection and enumeration of thermophilic Actinomycetes.

Sampled Nutrient agar plates were incubated at 30 °C to 32 °C (room temperature with natural light), 25 °C to 30 °C and 50 °C to 56 °C for fungi, environmental bacteria and thermophilic Actinomycetes respectively.

Enumeration

Concentrations of culturable microflora (Table 4) were reported as colony forming units (CFU)

Among the microorganisms present in the study area, bacteria were high in number as compared with fungi, despite their high death rate due to environmental factors producing stress of various kinds, of the major being dehydration stress.

Solid waste management at the training centre

Implementing environmental monitoring and management of solid waste depends on its composition (e.g. recyclable vs non-recyclable wastes). Composting of solid wastes reduces:

a. The level of leachate production by recycling the organic fraction of the waste stream
b. The total amount of waste by diverting some for alternative use
c. The overall cost of SWM and protecting the urban and nearby environment

Unsorted Municipal Waste, density of incoming waste, waste composition, organics, non-organic, etc were carried out. Solid Wastes including pre-consumer food residuals were collected from kitchen, pantry etc were segregated and then processed separately. A large quantity of organic waste is generated from the kitchens and is used for biogas.

The Composition and Sources of Solid Wastes

As shown in Table 6 the MSW physical composition were of high portion of organic waste (93%) and the remaining inorganic waste comprised of recyclables and non- recyclables materials.

E-waste

The growing awareness and sensitization of the increasing environmental impacts associated with e-waste and the development in the WEEE sector with the increasing occurrence of e-waste and its disposal have triggered initiatives World wide. The Sorting, Identifying, Usefulness, Identify hazardousness, Dismantling, Segregation and Treatment/Disposal are the steps involved in e-waste handling. The 2.5 tones

Table 1. Air analysis (outdoor) of the engineering industry

S.No.	Parameters	Units	Results	NAAQS Limits
1.	Location	--	Near Main Gate Area	--
2.	Date of Monitoring	--	23-03-2011	--
3.	Suspended Particulate Matter	µg/m3	190.2	500
4.	Respirable Particulate Matter	µg/m3	68.4	150
5.	Sulphur dioxide	µg/m3	26.3	120
6.	Oxide of Nitrogen	µg/m3	49.5	120
7.	Carbon monoxide	mg/m3	2	5.0
8.	Carbon dioxide	mg/m3	380	800
9.	Formaldehyde	ppm	Nil	2

Table 2. Air analysis (indoor) of the engineering industry

S.No.	Parameters	Units	Results	Limits	Specification Reference
1.	Location	--	Module -4 (Ground Floor Production Area)		-- --
2.	Date of Monitoring	--	23-03-2011	--	--
3.	Suspended Particulate Matter	ppm	2.9	15 ppm (Total)	OSHA
4.	Sulphur dioxide	ppm	0.75	--	OSHA
5.	Oxide of Nitrogen	ppm	1.60	5 ppm	OSHA
6.	Carbon dioxide	ppm	372	1000 ppm	OSHA
7.	Humidity	%	52	30-60 %	ASHRAE
8.	Temperature	°C	24	200 - 240 (Winter) 220 - 260 (Summer)	ASHRAE

Table 3. Average level of meteorological factors during the microflora sampling

S.No.	Location	Temperature (°C)	Relative humidity (%)
1.	Plant Engineering Department (Office)	29.9	46
2.	Kitchen	32.6	37
3.	Dining Hall	32.3	34
4.	Infotech (Gate I) Reception	30.4	40
5.	Production	27.6	38
6.	Out side near the main gate	29.2	39
7.	Medical Campus (Reception)	30.9	38

of hazardous e-waste were generated annually in the industry and the waste was sold to recyclers at Banglore (Table 7).

Litter management and mitigation

Inadequate provision can lead to ad hoc defecation in secluded areas on the site, thus creating unsanitary conditions and sources of fly infestation. Improper disposal of food cartons and other domestic forms of garbage could lead to littering of the site and pollution of adjacent area. Therefore, proper solid waste receptacles and storage containers should be provided, particularly for the disposal of lunch and drink boxes so as to prevent littering of the site. Arrangements should be made for the regular collection of litter and for its disposal.

Disposal/treatment practices for all solid wastes
Solid Waste Management

An audit was carried out to assess to what extent are the necessary conditions for the successful implementation of the waste wise policy in place. The management and control of the dump was investigated with regard to national health legislation and technical regulations. Reports and questionnaires were used for the audit. At present the solid waste collected is used for biogas plant on regular basis whereas the recyclable waste including paper etc is segregated for re-use. The Management is highly concerned by using eco-friendly technology for efficient use of organic waste collected from kitchen, pantry, backyard, lawn etc. The bio gas plant in the industry is excellent setup

Table 4. Air micro-flora analysis/enumeration in the engineering industry.

S.No.	Location	Microorganisms		
		Bacteria	Fungi	Actinomycetes
1.	Plant Engineering Department (Office)	Present Colony: 40 cfu	Present Colony: 14 mold	Absent: Colony: 0 cfu (No colony observed)
2.	Kitchen	Present Colony: 12 cfu	Present Colony: 46 mold	Absent: Colony: 0 cfu (No colony observed)
3	Dining Hall	Present Colony: 58 cfu	Present Colony: 45 mold	Absent: Colony: 0 cfu (No colony observed)
4.	Infotech (Gate I) Reception	Present Colony: 39 cfu	Present Colony: 3 mold	Absent: Colony: 0 cfu (No colony observed)
5.	Production	Present Colony: 64cfu	Present Colony: 13 mold	Absent:Colony: 0 cfu (No colony observed)
6.	Out side near the main gate (L&T)	Present Colony: 11cfu	Present Colony: 41 mold	Absent: Colony: 0 cfu (No colony observed)
7.	Medical Campus (Reception)	Present Colony: 4cfu	Present Colony: 4 mold	Absent: Colony: 0 cfu (No colony observed)

Table 5. Physical composition of MSW

S.No.	Parameters	Results %
1.	Total composted	93
2.	Plastics	5.0
3.	Coal	1.0
4.	Rags	0
5.	Misc	1

Table 6. Physicochemical composition of Solid wastes

S.No.	Parameters	Results
1.	pH	6.2
2.	Moisture %	55.14
3.	Organic matter %	59.05
4.	Carbon %	35
5.	Total Nitrogen %	0.87
6.	Total Phosphorus %	0.52
7.	C/N Ratio	40.22

for cooking purpose by using kitchen and household organic waste.

Potential environmental impacts from improper solid waste disposal

Potential hazards of solid wastes are numerous to the living community when it is improperly managed. Solid wastes have the potential to pollute all the vital components of living environment (i.e., air, land and water). Some of the hazards caused by solid wastes are listed below:

a. Uncollected wastes often end up in drains, causing blockages that result in flooding and unsanitary conditions

Table 7. Details of Hazardous wastes generated in the engineering industry

Hazardous waste disposal in the year Apr'10 –Mar '11		
Item	Qty	Disposed to
e-Waste disposed	2.5 tons	Ash Recyclers, Banglore

b. Flies breed in some constituents of solid wastes, and flies are very effective vectors that spread disease

c. Mosquitoes breed in blocked drains and in rainwater that is retained in discarded cans, tire and other objects. Mosquitoes spread disease, including Malaria and dengue

d. Rats find shelter and food in waste dumps. Rats consume and spoil food, spread disease, damage electrical cables and other materials and inflict unpleasant bites

e. The open burning of waste causes air pollution; the products of combustion include dioxins that are particularly hazardous

f. Aerosols and dusts can spread fungi and pathogens from uncollected and decomposing wastes

g. Uncollected waste degrade the environment. Plastic bags are in particular an aesthetic nuisance

h. Waste collection workers face particular occupational hazards, including strains from lifting, injuries from sharp objects and contact with pathogens when manually handling the waste

i. Dangerous items (such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans) may pose risks of injury or poisoning, particularly to children and people who sort

Fig. 4 Composition of Solid waste generation per day at Mysore Campus, L&T

through the waste

j. Waste items that are reused without being cleaned effectively or sterilized can transmit infection to later users

k. Polluted water (leachate) flowing from waste dumps and disposal sites can cause serious pollution of water supplies, ponds and lakes

l. Waste that is treated or disposed of in unsatisfactory ways can cause a severe aesthetic nuisance in terms of smell and appearance

m. Liquids and fumes, escaping from deposits of wastes (perhaps formed as a result of chemical reactions between components in the wastes), can have fatal or other serious effects

n. Methane (one of the main components of landfill gas) is much more destructive than carbon dioxide as a greenhouse gas, leading to climate change

o. Fires on disposal sites can cause major air pollution, causing illness and reducing visibility, making disposal sites dangerously unstable, causing explosions of cans, and possibly spreading to adjacent property

To implement proper waste management, various aspects have to be considered such as waste generation (source reduction), waste handling and sorting, storage and processing at the source (onsite storage), collection, sorting, processing and transformation, transfer and transport, and disposal.

Suggested techniques for solid waste management

The different types of processing techniques for solid waste management in the industry are given below:

a) Bio-chemical.

b) Aerobic composting

1. Indore composting method: 2. Fowler's method of activated composting:

3. Aerated Static Pile (ASP) composting:

4. In-vessel composting:

c) Composting / vermicomposting: (e.g. land filling).

Vermicomposting in the Industry

Observations on vermicomposting unit and comments

Based on survey conducted, it was observed that the industry is using efficiently organic waste materials collected from the campus for the vermicomposting process. The sample collected was stored in precleaned polyethylene bag for physicochemical analysis. Laboratory Analyses were performed using certified methodology from Standard Methods, APHA, 1995. The moisture content of vermicompost was calculated by the mass difference before and after drying at 105 °C to a constant mass. The pH and electrical conductivity (EC) were measured after 20 min of vigorous mixing samples at 1: 2.5: : solid : deionized water ratio using digital meters with a combination pH electrode and a 1-cm platinum conductivity cell respectively. Total nitrogen and total phosphorus were determined according to the Standard Methods of the American Public Health Association (1995). The organic carbon was determined by using Walkley–Black method. The dried sample was digested with concentrated nitric acid and 30% hydrogen peroxide and then determined by an atomic absorption spectrophotometer [AAS, Perkin Elmer] (APHA, 1995) for analysis of metal content. All the Physicochemical parameters (Table 8) were within the prescribed limits as per standard methods. However, the procedure practice has following inadequacy:

a. The absence of skilled staff for the composting / vermicomposting unit

b. The vermicomposting unit was not maintained adequately

c. The earthworms bedding, aeration, moisture contents, temperature etc. were not maintained

d. The populations of earthworms were not sufficient

Suggestions

Maintenance of composting unit

a. The incoming wastes at site shall be maintained prior to further processing.

b. To the extent possible, the waste storage area should be covered. If such storage is done in an open area, it shall be provided with impermeable base with facility for collection of leachate and surface water run-off into lined drains leading to a leachate treatment and disposal facility.

c. Necessary precautions shall be taken to minimise nuisance of odour, flies, rodents, bird menace and fire hazard

d. Pre-process and post-process rejects shall be removed from the processing facility on regular basis and shall not be allowed to pile at the site.

e. Ambient air quality monitoring shall be regularly carried out particularly for checking odour nuisance at down-wind direction on the boundary of processing plant.

b) Composting materials (for each composting unit)

The following parameters should be maintained

i. The physicochemical and biological characteristics

should be monitored during vermicomposting
ii. Organic waste materials should be of high lignin contents (dry leaves, grasses, coconut, fibers, vegetables etc.)
iii. Waste material should be in to 2-5 mm size and spread over the composting material
iv. The temperature (29.5-31°C) during the vermicomposting process should be maintained
v. The moisture content during vermicomposting should be maintained up to 45 to 55 % by watering
vi. The C/N ratio during and at the end of vermicomposting process should be maintained to 25:1 and 10:1 respectively
vii. The pH (6.5-6.8) of composting material should be maintained
viii. The partially decomposed cooled material should be used as bedding for earthworm

Kitchen waste biogas plant (KWBP)

Kitchen Waste Biogas Plant is a system which transforms the waste from kitchen (biodegradable) to biogas and in the process the manure is formed as a byproduct. It involves the principle of digestion through which the complex organic matter is broken down into simple molecules.

Waste → KW → biogas (product) + manure (by product)

This technology enables us to make use of the waste that is generated during cooking in an efficient manner. Further, the byproduct which is obtained in the form of manure will be rich in nutrients and hence it can be used as a soil conditioner for gardening purposes.

Table 8. Physicochemical charateristics of vermicompost.

S.No.	Parameters	Results
1.	Temperature	29.6 °C
2.	pH	6.73
3.	Moisture content	32.34 %
4.	Total Nitrogen	1.41 %
5.	Organic matter	68.80 %
6..	Carbon content	39.80 %
7	C/N ratio	1.724
	Minerals	
	a) Sodium (Na)	426.7 mg/kg
	b) Potassium (K)	2381.4 mg/kg
	c) Copper (Cu)	3.9 mg/kg
	d) Iron (Fe)	142.90 mg/kg
	e) Zinc (Zn)	31.3 mg/kg
	f) Calcium (Ca)	7656 mg/kg
	g) Magnesium (Mg)	4201.9 mg/kg

Solid Waste Management (SWM) is one of the burning issues in India. Apart from the generation of gas for meeting energy needs, Kitchen Waste Biogas Plant offers an ample scope for Solid Waste Management. 100 Kg of wet biodegradable waste yields $8m^3$ (approx.) of gas and 10 Kg of dry manure. Thus, the quantity of the waste is reduced by 90%. Apart from the savings in terms of money, the plant saves environment by reducing the waste which is intangible.

Noise measurement studies in campust

This assessment was accomplished by conducting a site–specific background–monitoring program and where appropriate, drawing comparisons to the applicable Ambient Air Quality Standards in Respect of Noise (AAQSRN). Noise levels were monitored in the study area to establish base line status. The anticipated in-plant noise sources are D.G Sets, Process Sections, Main Gate, Vehicular movement etc. The impacts of these identified sources were studied and their mitigation measures are included for attenuation of the noise.

Ambient Noise Level Standards are presented in (Table 11). Ambient Noise Level Monitoring was conducted at 9 locations in and around the industry. These monitoring locations and result were provided in Table 12.

Observation and Comments

The results of the monitoring program indicated that the morning, afternoon and evening time levels of noise were within the prescribed standards on all locations except in few locations.

Water environment

Recommendations for Best Practice Solutions to Minimize Wastewater

a. Leaks through preventive maintenance (check for excessive drift and splash) should be minimized
b. Proper level of corrosion inhibitors should be maintained to extend life of solutions
c. All float valves should be set within operating ranges
d. Alternative sources of grey water should be considered (i.e., rainwater harvesting)
e. Water should be reused in the process to achieve zero discharge
f. Many sites produce waste water condensate from compressor which may often be discharged straight to a water sewer, this water should be re-used and used as make-up water for cooling towers

Table 9. Savings per month through biogas plant in the industry.

SAVINGS	(in Rupees)
Savings per month through biogas	12096/-
Savings per month through manure	1800/-
Total Savings per month	13896-

Table 10. Technical specification of the biogas plant in the industry.

Technical specification of the biogas plant	
Input of waste per day	200Kg.
Generation of Biogas per day	12-18m3 (under ideal conditions)
Equivalent to LPG per day ($1m^3$ biogas=0.4 Kg)	4.8-6.4Kg.
Generation of Biogas per month	360-480m3
Equivalent to LPG per month	144-192Kg.
Equivalent to LPG cylinders	5 Cylinders/month (each commercial cylinder of 19 Kg.)
Cost of LPG per KG (at current commercial rate)	Rs. 63/-
Savings per day through Biogas	Rs. 63 X 6.4 Kg.
(Approx)	Rs. 403/-
Savings per month through Biogas	Rs. 63 X 192 Kg.
(Approx)	Rs. 12096/-
Generation of Manure per month (at 20kg/day)	600 Kg(depending upon raw material)
Minimum cost of Manure per day	Rs. 3/Kg.
Savings per month through Manure (Approx)	Rs. 1800

Table 11. Ambient Noise Level Standards

Area code	Category of Area	Limit in Db (A) Leq	
		Day Time	Night Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone	50	40

g. Vehicles should be washed in wash bays or other designated areas using grey water collected from other site operations and reused where possible
h. Label or color-code should be used to all drains surface water and effluent

It is realized that for many existing buildings, appropriate metering equipment for water consumption in various parts at the campus is not available. Therefore, to have appropriate water flow meters with sufficient accuracy should be installed in various water consuming areas such as kitchen, all the modules, guest house, hostel training centre, Medical Campus and is a prerequisite for carrying out a valid water conservation program.

Water quality and sampling locations

Information on water resources for both groundwater and surface was collected and assessed. Water resources were analyzed for physico-chemical (inorganic and organic) and bacteriological quality. The major water quality parameters considered for the analysis such as pH, temperature, Odor, Turbidity, electrical conductivity, total dissolved solid, chlorides, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals and microbiological parameters. The primary objective of water quality assessment is to determine water quality conditions and the nature and extent of present impacts. All samples collected were stored in pre-cleaned 1 litre polyethylene bottles. Bacterial samples are collected in sterilized 100 mL (glass bottles). Laboratory Analyses were performed using certified methodology from Standard Methods for Water and Wastewater Analyses (APHA, 1995). Sampling has been done following standard guidelines for physical, chemical and bacteriological parameters. Water sampling and analysis has been conducted to establish water quality in the area.

Physico-chemical and Microbiological Parameters of Drinking Water (Plant Engineering Department) (Tap Water)

Table 14 shows the physicochemical and microbiological characteristics of Drinking Water as compared

Table 12. Results of noise monitoring study in the engimeering campus.

S.No.	Location	Date	Morning Time		Afternoon Time		Evening Time	
			Reading Leq dB(A)	Limit Leq dB(A)	Reading Leq dB(A)	Limit Leq dB(A)	Reading Leq dB(A)	Limit Leq dB(A)
1.	Plant Engineering Department (office)	22/03/11	54.3	75	52.1	75	50.4	70
2.	Infotech Ground floor (mobile tech I)	22/03/11	56.2	75	52.5	75	50.1	70
3.	Infotech First floor (IES)	22/03/11	57.2	75	55.4	75	49.5	70
4.	Development center first floor, Module-VII (IES)	22/03/11	63.9	75	61.3	75	58.7	70
5.	Reception, (Modulel-X1) Center for Technology & Engineering Application	22/03/11	60.1	75	63.5	75	58.2	70
6.	Reception, Hostel (Module-XII)	22/03/11	57.6	75	59.3	75	55.1	70
7.	Conference room, Medical Campus	22/03/11	50.1	75	47.6	75	50.9	70
8.	Burn in area, Medical Campus	22/03/11	78.6	75	76.8	75	74.2	70
9.	Near Rain Water Harvesting area, Medical Campus	22/03/11	51.3	75	53.6	75	50.3	70

Table 13. Water sampling for Physico-chemical and Microbiological parameters

S.No.	Water Samples
1.	Plant Engineering Dep.(Tap water).
2.	Plant Engineering Dep. after Aqua guard filter treatment.
3.	Equipment Manufacturing Dept. (Municipal water)

with the standard (IS 10500: Indian Standards/Specifications for Drinking Water) reference values. The pH, Electrical conductivity and TDS recorded in drinking water sample were 7.28, 62.4 µS/cm and 4.7 mg/L respectively. It can be concluded that certain parameters like, pH temperature, EC & chloride were found to under permissible limit in water sample. Parameters like TDS, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals etc. were found under permissible limit. Therefore water sample for drinking found under permissible limit, i.e. satisfactory; suitable for drinking. The drinking water shows the absence of Total Coliform, *E. coli, S. aureus* and *Pseudomonas* spp. The average microbiological plate count values were 3.3 X 10′ cfu/mL.

Physico-chemical and Microbiological Parameters of Drinking Water (After Aquaguard fillter treatment)

Table 15 shows the physicochemical and microbiological characteristics of Drinking Water as compared with the standard (IS 10500: Indian Standards/Specifications for Drinking Water) reference values. The pH, Electrical conductivity and TDS recorded in drinking water sample were 7.05, 84.21 µS/cm and 3.5 mg/L respectively. It can be concluded that certain parameters like, pH temperature, EC & chloride were found to under permissible limit in water sample. Parameters like TDS, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals etc. were found under permissible limit. Therefore water sample for drinking found under permissible limit, i.e. satisfactory; suitable for drinking. The drinking water shows the absence of Total Coliform, *E. coli*, *S. aureus* and *Pseudomonas* spp. The average microbiological plate count values were 3.3 X 10′ cfu/mL.

Physico-chemical and Microbiological Parameters of used in the industry

Table 16 shows the physicochemical and microbiological characteristics of Drinking Water as compared with the standard (IS 10500: Indian Standards/Specifications for Drinking Water) reference values. The pH,

Electrical conductivity and TDS recorded in drinking water sample were 7.65, 80.5 µS/cm and 5.2 mg/L respectively. It can be concluded that certain parameters like, pH temperature, EC & chloride were found to under permissible limit in water sample. Parameters like TDS, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals etc. were found under permissible limit. Therefore water sample for drinking found under permissible limit i.e. satisfactory; suitable for drinking. The drinking water shows the absence of Total Coliform, *E. coli*, *S. aureus* and *Pseudomonas* spp. The average microbiological plate count values were < 10' cfu/mL.

Suggestions

a. Although the metal contents were below levels, however regular monitoring of the metal pollution of these areas should be enforced so that there would not be any increase in the total weekly intake of these metals above tolerance levels. This study has shown that the entire water sample meets the standard limits for the trace metals and the physico-chemical properties. It means that water is not polluted. However, regular monitoring should be ensured by the authorities concerned.
b. In order to ensure optimum operation of a water treatment plant, the following critical points must be monitored regularly: raw, sedimentation, filtration, treatment and tap points.
c. Both physicochemical and microbial parameters should always be kept within the recommended limits.
d. It is recommended that raw water be monitored at all times for proper applications.
e. One major recommendation for this study would be to make sure that the water from each plant complies with the standards before distribution.

Rainwater harvesting in the industry

The Rainwater harvesting is the simple collection or storing of water through scientific techniques from the areas where the rain falls. It involves utilization of rain water for the domestic or the agricultural purpose. The method of rain water harvesting has been into practice since ancient times. Rain water harvesting comprises of storage of water and water recharging through the technical process. Rainwater harvesting first of all increases water security. It is the perfect solution to meet water requirements especially in the areas which do not have sufficient water resources. It helps in improving the quality of the ground water and increasing the level of the ground level. It reduces the loss of top layer of the soil. Rain water harvesting reduces the flooding on roads and further prevents it from contamination. Rainwater harvesting is made mandatory for group housing societies and for certain large sized residential, commercial and industrial complexes in India.

Disadvantages of Rainwater Harvesting

1. The water used for harvesting is full of pollutants leading to health problems.
2. Polluted environment results in:
a. Increasing amount of nitrates and fluorides in the water
b. High content of cadmium, lead, iron and chromium in the water
c. Bacteriological contamination levels are rising in water

Advantages of Rainwater Harvesting

a. An ideal way to solve the water problem
b. The ground water levels will rise
c. It reduces the runoff which chokes the storm water drains
d. It reduces flooding of roads, also reducing soil erosion
e. The quality of water improves
f. Power consumption is reduced as a one-metre rise in water levels results in saving 0.4 Kw H of electricity

The locations and quantity of Rain Water Harvested every year in the campus is shown in (Table 17). The samples collected from the Rain Water Harvesting System were stored in pre-cleaned polyethylene bottles for analysis. Laboratory Analyses were performed using certified methodology from Standard Methods.

Observations and comments on Rain Water Harvesting System

Based on survey conducted, it was observed that the industry is using efficiently Rain Water Harvesting Systems for collection of surface runoff rain water. However, the procedure practice has following inadequacy:
a. The absent of skilled staff for the Rain Water Harvesting System
b. All the Rain Water Harvesting Systems were not maintained sufficiently
c. Presence of algal blooms (eutrophication), mosquito's larva, insects etc. in the Rain Water Harvesting Systems

Table 14. Physico-chemical and Microbiological parameters of Drinking water Plant Engineering Dept. (Tap water)

S.No.	Parameters	Drinking water –	Limits
1.	pH	7.28	6.5 to 8.5
2.	Taste	Agreeable	-
3.	Odor	Unobjectionable	-
4.	Conductivity µS/cm	62.4	-
5.	Total suspended solids (TSS) mg/L	4	-
6.	Total Dissolved solids (TDS) mg/L	4.7	500
7.	Chloride mg/L	60.26	250
8.	Fluoride mg/L	0.080	1.0
9.	Sulphate mg/L	Nil	200
10.	Total Hardness mg/L	10	300
11.	Calcium mg/L	8	75
12.	Magnesium mg/L	2	30
13.	Sodium mg/L	45.04	-
14.	Potassium mg/L	1.24	-
15.	Nitrate mg/L	Nil	45
16.	Inorganic Phosphorus mg/L	Nil	
17.	Heavy metals a) Pb	< 0.1 mg/L	
	b) As	< 0.1 mg/L	
	c) Zn	< 0.1 mg/L	
	d) Cu	< 0.1 mg/L	
	e) Fe	< 0.1 mg/L	
	f) Cd	< 0.05 mg/L	
18.	Microbiology : Plate count	3.85 X 10′ cfu/mL	
	E coli	Absent	
	Pseudomonas	Absent	
	S. aureus	Absent	

d. Presence of plastic bags, dry leaves, paper, mud's, etc. in the Rain Water Harvesting Systems

Suggestion and Maintenance

a. An effective system requires minimal, but regular maintenance. Clean inside of the reservoir yearly
b. Minimize the amount of debris
c. To reduce algae growth, which could clog up the system or slow down water flow, clean the system on a regular basis
d. Set up an efficient design for the irrigation system based on the water-use zones. Water only when necessary and early morning watering is best
e. Storage tanks should be covered to prevent mosquito breeding and to reduce evaporation losses, contamination and algal growth

Existing situation of sewage treatment plants in the industry

Table 18, shows the physicochemical characteristics of Sewage treatment plant (Near Module-VII) in the campus and were compared with the standards IS 3025 and APHA (American Public Health Association) for wastewater reference values. All the parameters were within the prescribed limits as per IS 3025 and APHA.

Table 19, shows the physicochemical characteristics of Sewage treatment plant near Module-XII and were compared with the prevailing standards for wastewater reference values. All the parameters were within the prescribed limits (except COD). The value of COD is high in inlet (272 mg/L) and outlet (280 mg/L) samples, therefore the treatment need to be corrected.

Table 20, shows the physicochemical characteristics of Sewage treatment plant at Medical Campus and were compared with the prevailing standards. All the parameters were within the prescribed limits (except COD).

Sewage treatment plant at medical campus

Observations and Comments

1. The STP is provided with Fluidized Aerobic Bioreactor (FABR) system.
2. Sewage water is pumped in FABR Tank with uncontrolled flow. Raw sewage should be transferred under control process, for this bypass line should be

Table 15. Physico-chemical and Microbiological parameters of Drinking Water (After Aqua guard filter treatment.

S.No.	Parameters	Drinking water –	Limits
1.	pH	7.05	6.5 to 8.5
2.	Taste	Agreeable	-
3.	Odor	Unobjectionable	-
4.	Conductivity µS/cm	84.21	-
5.	Total suspended solids (TSS) mg/L	3	-
6.	Total Dissolved solids (TDS) mg/L	3.5	500
7.	Chloride mg/L	49.63	250
8.	Fluoride mg/L	0.037	1.0
9.	Sulphate mg/L	Nil	200
10.	Total Hardness mg/L	8	300
11.	Calcium mg/L	6	75
12.	Magnesium mg/L	2	30
13.	Sodium mg/L	24.2	-
14.	Potassium mg/L	1.21	-
15.	Nitrate mg/L	Nil	45
16.	Inorganic Phosphorus mg/L	Nil	
17.	Heavy metals a) Pb	< 0.1 mg/L	
	b) As	< 0.1 mg/L	
	c) Zn	< 0.1 mg/L	
	d) Cu	< 0.1 mg/L	
	e) Fe	< 0.1 mg/L	
	f) Cd	< 0.05 mg/L	
18.	Microbiology: Plate count	3.3 X 10′ cfu/mL	
	E coli	Absent	
	Pseudomonas	Absent	
	S. aureus	Absent	

provided at pump to avoid the shock load in Aeration Tank.

Air environment

An assessment of air quality was undertaken to establish the status of exposure of the receptors. This assessment was accomplished by examining sources of air emissions within the study area, and by conducting a site–specific background–sampling program. The three sampling regions were selected, i.e. 1. Near main gate for ambient air sampling 2. Module IV (production area) for Indoor air sampling and 3. D.G. set (625 KVA for stack monitoring). The air environment around the industry is free from any significant pollution source. Therefore, ambient air quality is quite good in and around the area. SPM and RSPM levels were observed to be normal. All the other parameters were observed to be well within the prescribed standards.

Airborne microflora

In the present study, outdoor and indoor airborne microflora (bacteria) at different locations was investigated during summer season on 23rd March, 2011.Among the microorganisms present in the study area, bacteria were the highest in number as compared with fungi and actinomycetes. Appropriate hygienic condition, dust control, bactericidal vapours, and fumigation should be carried out periodically.

Noise monitoring program

Ambient Noise Level Monitoring was conducted at 9 locations in and around the industry. The results of the monitoring program indicated that the morning, afternoon and evening time levels of noise were within the prescribed standards on all locations (except in few areas), low voice speaking, reducing the noise levels from domestic sectors, maintenance of machines, green belt development, using protection equipment, job rotation, exposure reduction, equipment like earmuffs, ear plugs etc. should be recommended.

Solid waste Management

Solid Wastes including pre-consumer food residuals were collected from kitchen, pantry etc. were segregated and then processed separately. Physical compositions of solid waste were of high portion of organic waste (93%) and the remaining inorganic waste

Table 16. Charateristics of Municipal Drinking waterused in the industry.

S.No.	Parameters	Drinking water –	Limits
1.	pH	7.65	6.5 to 8.5
2.	Taste	Agreeable	-
3.	Odor	Unobjectionable	-
4.	Conductivity µS/cm	80.5	-
5.	Total suspended solids (TSS) mg/L	2	-
6.	Total Dissolved solids (TDS) mg/L	5.2	500
7.	Chloride mg/L	56.72	250
8.	Fluoride mg/L	0.086	1.0
9.	Sulphate mg/L	Nil	200
10.	Total Hardness mg/L	12	300
11.	Calcium mg/L	8	75
12.	Magnesium mg/L	4	30
13.	Sodium mg/L	49.37	-
14.	Potassium mg/L	1.62	-
15.	Nitrate mg/L	Nil	45
16.	Inorganic Phosphorus mg/L	Nil	
17.	Heavy metals a) Pb	< 0.1 mg/L	
	b) As	< 0.1 mg/L	
	c) Zn	< 0.1 mg/L	
	d) Cu	< 0.1 mg/L	
	e) Fe	< 0.1 mg/L	
	f) Cd	< 0.05 mg/L	
18.	Microbiology: Plate count	< 10′ cfu/mL	
	E coli	Absent	
	Pseudomonas	Absent	
	S.aureus	Absent	

comprised of recyclables and non- recyclables materials. Proper solid waste receptacles and storage containers should be provided. Therefore to implement proper waste management, various aspects should be considered such as waste generation (source reduction), waste handling and sorting, storage and processing at the source (onsite storage), collection, sorting, processing and transformation, transfer and transport, and disposal.

E-Waste

The 2.5 tones of hazardous e-waste were generated annually at the Campus, and the waste was sold to recyclers at Banglore. To control the hazardous effect of e-waste, the steps such as Sorting, Identify Usefulness, Identify hazardousness, Dismantling, Segregation, Treatment/Disposal/ash etc. should be adopted.

Physicochemical characteristics of drinking water

The major water quality parameter was considered for the analysis such as pH, temperature, Odor, Turbidity, electrical conductivity, total dissolved solid, chlorides, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals and microbiological parameters. The primary objective of water quality assessment is to determine water quality conditions and the nature and extent of present impacts. The drinking water samples evaluated in the study area were from various locations. All the samples of drinking water show the absence of *E. coli*, *S. aureus* and *Pseudomonas* spp. It can be concluded that certain parameters like, pH temperature, EC & chloride were found to under permissible limit in water sample. Parameters like TDS, calcium, magnesium, sulphate, fluoride, nitrate, potassium, total hardness, heavy metals etc. were found under permissible limit. Although the metal contents were below levels, however regular monitoring of the metal pollution of these areas should be enforced so that there would not be any increase in the total weekly intake of these metals above tolerance levels. This study has shown that the entire water sample meets the standard limits for the trace metals and the physico-chemical properties. It means that water is not polluted. However, regular monitoring should be ensured by the authorities concerned.

Table 17. Locations and quantity of Rain Water Harvested every year in Mysore

Rain Water Harvesting System	Length (ft)	Width (ft)	Depth (ft)	Quantity in Cft	Quantity in Cum	Quantity of water in L	Quantity water in L lts
Near R&D Building	80	30	16	38400	1086.59	1086587.44	10.86 L lts
Behind Infotech	Building	175	25	12	52500	1485.571485568.76	14.85L lts
Near Scrap Yard	164	49.2	12	96825.6	2739.83	2739830.22	27.40 L lts
Near STP	56	23	8	10498	297.06	297060.00	3.00 L lts
Behind Emsys car parking	60	25	16	24000	679.12	679117.15	6.80 L lts
Near Hostel Block	75	20	8	12000	339.56	339558.57	3.40 L lts

Table 18. Charateristics of waste water in the Sewage treatment plant of the industry

S.No.	Parameters	Inlet	Outlet	Limit
1.	pH	6.71	7.01	5.5 to 9
2.	Total suspended solids (TSS)	208	16	100
3.	Total Dissolved solids (TDS)	1164	1096	2100
4.	Chloride mg/L	319.05	354.5	
5.	Fluoride mg/L	0.14	0.13	15
6.	Sulphate mg/L	70	60	-
7.	Calcium mg/L	149.2	118.4	-
8.	Magnesium mg/L	104.8	83.1	-
9.	Sodium mg/L	154.6	137.2	
10.	Potassium mg/L	45.3	30.9	-
11.	Total Nitrogen mg/L	5.60	5.37	-
12.	Total Phosphorus mg/L	3.40	2.14	
14.	COD mg/L	248	216	250
15.	BOD mg/L	20	18	350
16.	Heavy metals mg/L a) Pb	< 0.1	< 0.1	1.0
	b) As	< 0.1	< 0.1	0.2
	c) Zn	0.5	0.3	15
	d) Cu	0.1	< 0.1	3
	e) Fe	0.1	0.8	-
	f) Cd	< 0.05	< 0.05	2
	g) Hg	< 0.1	< 0.1	

Rain Water Harvesting System

Based on survey conducted, it was observed that the industry is using efficiently Rain Water Harvesting Systems for collection of surface runoff rain water. However, the procedure practice has insufficiency in terms of absence of skilled staff, maintenance, presence of algal blooms (eutrophication), mosquito's larva, insects etc. Regular maintenance, cleaning inside of the reservoir yearly, controlled of algal growth is recommended. The Rain Water (Harvesting systems) shows the presence of waterborne pathogens *E. coli*, *Pseudomonas* spp, *Staphylococcus aureus* and high density of algal blooms. Dominance of class Chlorophyceae in rain water harvesting systems is due to high dissolved oxygen and fair amount of pH, alkalinity and total hardness. Some of algal blooms were recorded as Nostoc, *Chlorella vulgaris, Spirogyra* sp, *Zygnema, Navicula, Closterium* sp., *Scenedesmus* etc. Reduction in the amount of nutrients, such as garden fertilizers, leaves and other organic garden waste, near the Rain water Harvesting Systems, Separation of the Rain Water Harvesting Systems from the rest of the garden with a physical rainwater runoff barrier such as a stone or concrete path, installation of drainage channels between the garden and the Rain Water Harvesting Systems to divert nutrient-rich rainwater runoff away from the systems is recommended. Plants such as anacharis should be used which grows underwater, will take up many of the nutrients in the Rain Water Harvesting Systems, cutting the food supply to algae and preventing blooms from forming. If all the mentioned measures fail, suitable algaecide (copper sulphate) has to be used.

Table 19. Charateristics of waste water at the Sewage treatment plant near Module-XII in the industry

S.No.	Parameters	Inlet	Outlet	Limit
1.	pH	6.51	7.02	5.5 to 9
2.	Total suspended solids (TSS)	248	67	100
3.	Total Dissolved solids (TDS)	1174	848	2100
4.	Chloride mg/L	389.95	283.6	
5.	Fluoride mg/L	0.16	0.12	15
6.	Sulphate mg/L	45	44	-
7.	Calcium mg/L	176.7	182.9	-
8.	Magnesium mg/L	112.7	120.6	-
9.	Sodium mg/L	153.0	193.8	
10.	Potassium mg/L	28.8	44.2	-
11.	Total Nitrogen mg/L	8.06	3.58	-
12.	Total Phosphorus mg/L	3.05	1.84	
14.	COD mg/L	272	280	250
15.	BOD mg/L	26	20	350
16.	Heavy metals mg/L a) Pb	< 0.1	< 0.1	1.0
	b) As	< 0.1	< 0.1	0.2
	c) Zn	0.5	0.8	15
	d) Cu	< 0.1	0.1	3
	e) Fe	3.0	3.0	-
	f) Cd	< 0.05	< 0.05	2
	g) Hg	< 0.1	< 0.1	

Table 20. Charateristics of waste water treatment at Medical campus Sewage treatment plant in the industry.

S.No.	Parameters	Inlet	Outlet	Limit
1.	pH	7.74	7.45	5.5 to 9
2.	Total suspended solids (TSS)	102	92	100
3.	Total Dissolved solids (TDS)	915	1641	2100
4.	Chloride mg/L	354.5	354.5	
5.	Fluoride mg/L	0.17	0.14	15
6.	Sulphate mg/L	40	38	-
7.	Calcium mg/L	352.1	371.7	-
8.	Magnesium mg/L	190.0	191.4	-
9.	Sodium mg/L	162.8	186.0	
10.	Potassium mg/L	24.5	30.0	-
11.	Total Nitrogen mg/L	7.16	6.83	-
12.	Total Phosphorus mg/L	3.55	3.05	
14.	COD mg/L	224	200	250
15.	BOD mg/L	24	18	350
16.	Heavy metals mg/L a) Pb	< 0.1	< 0.1	1.0
	b) As	< 0.1	< 0.1 t	0.2
	c) Zn	0.8	2.1	15
	d) Cu	< 0.1	0.1	3
	e) Fe	0.5	3.3	-
	f) Cd	< 0.05	< 0.05	2
	g) Hg	< 0.1	< 0.1	

Sewage Treatment Plants

The physicochemical characteristics of Sewage treatment plants (Near Module-VII, Module-XII - Sandeepani Hostel and Medical Campus) in the industry were compared with the prevailing standards for wastewater reference values. All the parameters were within the prescribed limits (except COD in case of Sewage treatment plant near Module-XII-Sandeepani Hostel). The value of COD is high in inlet (272 mg/L) and outlet (280 mg/L) samples, therefore

the treatment need to be corrected. The leakage was observed in Filter feed pump, proper Feed well (cylindrical shell with specific diameter) should be provided in settling tank for proper separation of sludge and water. The treated water was slightly turbid indicating poor tertiary filtration. It is advised to change filter media after every 8-10 months. UV system provided for disinfection of treated sewage water. The Filter media (Sand and Activated Carbon) should be replaced by new media for proper filtration. It is advised to change filter media after every 8-10 months.

Health status of workers/employees should be examined quarterly by certified/qualified doctors as there are presences of mold infection /use of sewage water in the campus.

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