Executive Summary

Introduction

The Municipal solid waste (MSW) generated in most of the Indian cities and towns are being disposed off on open land due to several technical, financial, institutional and social constraints. The State of Goa is no exception to this reality. In spite of existence of various Acts, Rules and Regulations pertaining to MSW management, the problem of garbage management in the State is mounting day by day.

Govt. of Goa has taken an initiative to establish a Centralized Municipal Solid Waste management Facilities (CMSWMF) at an existing MSW dumpsite located at Cacora Village of Quepem Taluka in South Goa district of the State **to comply with the Orders of the Hon'ble High Court vide the Suo Motu Writ Petition 2/2007 and the requirements as per MSW Rules 2000**. The main objective of the establishment of CMSWMF is to process and dispose-off the waste lying haphazardly at the existing MSW dumpsites site and also to cater to the needs of present, as well as future waste generated in the South Goa district.

The Government of Goa is implementing this project through Department of Science Technology & Environment (DST&E) and Goa State Infrastructure Development Corporation Ltd. (GSIDC). DST&E is the nodal department, whereas GSIDC is the executing agency for the project. The proposed CMSWMF will be of 100 tons per day (TPD) / 36,500 tons/annum (TPA) capacity based on Recycle & Sorting Line, Segregation, Bio-methanation and In-vessel Composting at Cacora in South Goa District.

The CMSWMF is being established on Design, Build, Finance, Own and Transfer (DBFOT) basis with 100% financing by "Concessioner" (contractor) which was selected through a tendering procedure. The scope of work for Concessioner includes Design, Engineering, Financing, Procurement, Supply, Installation, Construction, Testing and Commissioning of all Civil, Mechanical, Electrical and

Instrumentation Works along with 10 (ten) years' Operation & Maintenance of the entire facility. A tripartite "Concession Agreement" has already been signed among DST&E, GSIDC, and Concessioner.

As a part of procedure for establishing the said CMSWMF, DST&E / GSIDC has applied for obtaining Environmental Clearance (EC) from State Environmental Impact Assessment Authority (SEIAA) and GSIDC retained National Environmental Engineering Research Institute (NEERI), Nagpur in July 2014 to conduct the EIA study for the proposed MSW processing facility.

As per the information collected from various records and reports available with Govt. of Goa, the existing MSW dumpsite at Cacora, South Goa is severely contaminated due to unscientific disposal, thereby posing serious risk to air, soil, surface water, and groundwater resources in and around the existing site. The proposed CMSWMF, which is technically and environmentally sound, is expected to minimize / eliminate the negative environmental impacts caused due to indiscriminate dumping of un-segregated MSW in the past 20 years.
It is in this context, a holistic approach has been followed, while planning the integrated MSW treatment facility for South Goa. The proposed CMSWMF facility will be a state-of-the-art modern facility, based on mechanical-biological treatment process with proper segregation and bio-methanation technology. **The technology selected for the proposed CMSWMF is as per the requirements of MSW Rules 2000, and in accordance with the Guidelines of Central Pollution Control Board (CPCB)**. The detailed project report of the CMSWMF as prepared by Concessioner was vetted by a scientific expert committee constituted by GSIDC.

The Govt. of Goa has selected existing MSW dumpsite located at Survey No. 167 and 168 of Cacora village of Quepem Taluka, in South Goa District for establishment of proposed CMSWMF, with an aim of restoration of environmental quality in and around the existing dumpsite, as well as environmentally sound management of present and future waste generation in the South Goa District.The exact location of the facility is 150 13' 55.85" North Latitude and 740 07' 30.08" East Longitude.

The proposed location for the facility is surrounded by town Curchorem and Cacora in the North, Muguli Village in the East, Sanguem town in South and Village Karmaliwada in the West. It is further surrounded by the villages of Devamal, Dande, Karmaliwada, Muguli, Theorlimal, Tamtamardi, Madegal, Gadlawhada etc. The site is 34.78 km from Vasco de Gama, 6.3 km from Ugem, and 6.2 km from Salelum reservoir. The nearest railway station Churechorem is located at 3.91km from site and Dabolim airport is located at 34 km from the site.

As informed by GSIDC, the land required for CMSWMF has already been acquired and notified as "Industrial Area". The proposed site has the only road access from the Churechorem. GSIDC is presently constructing appropriate access road from Churechorem road to the MSW site for vehicle movement specifically for transportation of MSW to the facility. The access road is already congested as it is being used for movement of raw materials, products, plant and machinery for the existing industries near the proposed CMSWMF site at Cacora.

Climatologically, the regional conditions of the project area experiences coastal weather conditions (Typical of western coast of India) with special reference to ambient temperature. The ambient temperature in the region is found to vary from 18.0^{O}C to 38.0^{O}C during post-monsoon (Oct. - Dec., 2014). The average rainfall in this region is about 3000 mm per year. The mean wind speed has been recorded more than 3 kmph. The predominant wind direction is from NE-SW during post-monsoon season with significant land / sea breeze phenomena.

Description of Project

The proposed CMSWMF will be a state-of-the-art modern facility based on mechanical biological treatment (MBT) processes with proper waste segregation and bio-methanation technology and shall cater to 3-3.5 Lakhs population @ 0.3-0.35 kg/day/person. It shall cover the area of Quepem Taluka and its surrounding villages, which generates high amount of waste due to local and tourist population. As per the tripartite concession agreement signed between GSIDC, DST&E and Concessionaire the responsibility of collection and transportation of MSW generated in the South Goa district shall be by Govt. of Goa. This will be done through the local

authorities. The mixed MSW will be collected and transported in closed trucks to the CMSWMF.

The municipal solid waste in South Goa district is generated from households and commercial establishments like offices, hotels, restaurants, vegetable markets, and slaughterhouses. Besides these there is also a large fraction of tree wastes and street sweepings which will be collected and processed at the CMSWMF. It is estimated that approximately 100 tonnes per day (TPD) of mixed MSW will be generated, collected and processed at the CMSWMF.

The facility will have minimum human intervention, enclosed sheds, and programmable logic controller / supervisory control and data acquisition (PLC / SCADA) controlled equipment for handling different types of input material. Selection of technology and its functioning has been done with a major focus on the issues pertaining to odors, unsightly garbage mounds, leachate generation and their scientific management with the goal of minimizing the same. The entire plant operation shall be carried out using the electricity produced in-house from the organic fraction of the MSW. Besides all essential infrastructures, efforts are being taken for information dissemination by providing an in-house auditorium / resource center for displaying the recycling and waste treatment process, gardens, public conveniences and café for encouraging public tours. The facility shall not only serve as a tourist attraction, but also as learning center to create awareness about the positive environmental impact of the solid waste treatment facility in the State of Goa. This would also facilitate image building of the State Govt. with respect to environmental restoration. The technical details on proposed CMSWMF, divided into four major Sections are described below:

- **Material Segregation & Recovery Center (MSRC)**

Mixed / segregated waste collected in open trucks /compactors and delivered at the facility shall be taken to the Tipping Floor area, housed in an enclosed Shed of the MSRC. The Shed shall be covered and have adequate height with proper arrangement for lighting and ventilation. The Tipping Floor area shall be provided with an Odour Control System comprising air blowers, air ducting and air adsorbing Bio-filter to ensure that mal odorous gases are effectively sucked and adsorbed in

the Bio-filter.

The main function of the MSRC is to segregate and recover maximum possible recyclables from the mixed waste such that they can be directly reused. Recyclable and sorted materials shall be baled and wrapped for reuse as per the Buyers' / Vendor's requirements. Remaining waste left after sorting and recovering recyclables shall be shredded and / or compacted as Refuse Derived Fuel (RDF) and residual material, which cannot be converted into RDF, will be taken to the Landfill Cells.

Electronic Waste (E-waste) comprising electronic wastes e.g. phones, printer cartridges, compact discs, etc. received into the facility from households shall be sorted at the Tipping Floor / Manual Sorting Station and taken to the E-Waste Storage area / container. E-waste shall be disposed of suitably as per applicable statutory norms.

The household hazardous waste e.g. batteries, bulbs / tube lights etc. and bio-medical waste received, if any shall be stored and disposed as per applicable statutory rules pertaining to hazardous and bio-medical waste.

- **Treatment of Wet / Bio-degradable / Organic Waste**

The main function of this Section is to digest the organic fraction using a **bio-methanation** process and **generate electricity via biogas**. The electricity thus, produced shall be used to run the plant and reduce the operating expenses. The pulped wet fraction from the organic extrusion press shall be conveyed into the bio-methanation fermenter. The fermenter shall be provided with mixers and a heating arrangement to ensure digestion of the contents takes place in a thermophilic range of 55^0 C. Waste heat from biogas engines shall be used for heating the fermenter. After completing the digestion step, the digested substrate shall be transferred to Sludge Dewatering Unit.

The digested substrate shall be separated into solid (dewatered sludge) and liquid (concentrate / filtrate) phases in a dewatering unit. The dewatered sludge shall be then transported to **In-Vessel Composting Drums** area via Skid Stir Loader / Wheel Loader. The concentrate can be recycled back into the buffer tank and fed

into the digester. Part of the concentrate shall be pumped to the effluent treatment plant for further treatment and recycled within the plant for various uses like gardening, landfill application or composting purpose.

The dewatered sludge from dewatering equipment shall be transferred to the **In-vessel composting drums** area using a Skid Stir Loader / Wheel Loader. Wood chips / mulched tree waste shall be added as structural material to dewatered sludge to improve voidage and therefore to improve compost efficiency. The mixed input material shall be fed into the **in-vessel composting drums** using a conveyor mechanism. The drums shall be rotating continuously and the composting of the mixed sludge takes place in an accelerated manner within 4-6 days due to continuous rotation of the enclosed drums. The vessel shall have an air vent to be connected to a bio-filter for odour control. After **in-vessel composting**, the compost material shall be further stored and matured for a period of minimum 14 days in a Shed. After maturation, the compost shall be screened to separate structural materials using a Star Screen of 10 – 30/10 mm screening capacity. The large sized fraction can be grinded and mixed with the input dewatered sludge as structure material. The finer fraction shall be bagged for further sale as per requirement.

The fermentation of organic residues in an anaerobic atmosphere in the Bio-methanation Units shall generate biogas, 50% – 70% of which shall be methane. The biogas shall be stored in an integrated Double Membrane type Gas Holder Dome anchored on the top of the Concentrate/Filtrate tank. This biogas shall be cleaned for removal of H_2S and moisture to suit the operation of Biogas Genset / Micro Turbine for generation of electricity. Biogas cleaning shall preferably be carried out prior to storage in the Gas Holder Dome. Electricity as generated shall be utilized to run the entire processing facility including Process Units, Lighting, Ventilation etc. and various auxiliaries of the Biogas based Power Plant (Genset / Micro Turbine). A part of thermal energy (waste heat) generated during this process shall be used for heating the contents of the Bio-methanation Units.

- **Landfill of residual inert material**

The inert (inorganic) residual material, generated during the processing of the waste, shall be landfilled. The landfilling of organic waste shall not be permitted and

no organic fraction is disposed in the landfill. All such inert material shall be typically generated as residual material from Sorting Station, which cannot be converted into RDF. The landfill area shall be constructed as per MSW 2000 guidelines with proper lining arrangement. Proper access and approach roads shall be provided along the landfill for easy transport and filling operation. Land filled material shall be weighed daily on the weighbridge prior to dumping. The logged data shall form the basis to ascertain the quantum of daily inert fraction going for landfill as per the performance guidelines. The life of Landfill cells shall be developed for a period of 10 years.

- **Other Miscellaneous Common Facilities**

The Sheds, Buildings, Infrastructure viz., roads and pathways, storm water drains, truck and vehicle parking area, main gates at entry / exit points, raw water tank and water distribution network, plantation/gardening/landscaping, fire fighting system, etc. and Mobile equipment are the miscellaneous common facilities to be created for the smooth operation of the CMSWMS.

Description of Environment

Air Environment

To establish baseline air quality status for proposed project five locations were identified in 5 km radius study area for ambient air quality monitoring during post-monsoon season. The conventional air pollutants were monitored as 24 hourly averages, whereas VOCs were monitored as spot concentrations.

The 24 hourly concentrations of Particulate Matter (PM_{10} and $PM_{2.5}$) in the rural/residential area during post-monsoon season are ranged for PM_{10} from 27.2 to 53.6 μg/m³ and for $PM_{2.5}$ from 8.0 to 19.6 μg/m³. The levels of PM_{10} and $PM_{2.5}$ at all sampling locations in the study area were well below the prescribed limit of 100 & 60 $\mu g/m^3$ respectively for air quality standards for Industrial area, residential, rural & other areas as well as industrial areas.

The 24 hourly values of each of the parameters viz. SO_2, NOx, NH_3, O_3, Benzene, Pb, As, Ni, BaP monitored were found to be well within the limits prescribed in the National Ambient Air Quality Standards (NAAQS) for Industrial

area, residential, rural & other areas as well as industrial areas, notified in November 2009

In addition, VOC's specific to MSW dumping sites were also monitored at the site and surrounding. Amongst the list of probable VOC's usually detected in and around the uncontrolled MSW dumping sites, VOC's actually detected in spot samples collected in and around the existing dump site were acetaldehyde, formaldehyde, formic acid, diacetylsulphide, dimethyl sulphide, dimethyl disylphide, propionic acid, acetic acid.

Noise Environment

Equivalent noise levels (Leq) at five different locations around the proposed CMSWMF site have been measured during daytime and night-time. The noise levels in study area vary between 33.2 - 44.2 dBA during day time and 27.3 – 33.2 dBA during night time. Highest noise levels were recorded during day time at Tilamola location (44.2 dBA), while during night time the highest recorded was also at the same location.

Water Environment

In order to generate the baseline water quality (physico-chemical and biological) of the region, 17 sampling locations in and around Common Municipal Solid Waste Management Facility at Cacora, South Goa were identified.

The overall physico-chemical characteristics of surface and ground water samples showed acidic to neutral nature of water with pH ranging from 5.1-7.3 and low to moderate mineral content as evident from TDS values of 40-128 mg/l. Presence of heavy metals viz. Fe and Cr especially in ground water, low values of DO (2.2-5.6 mg/l) and comparatively higher values of COD (10-28 mg/l) in water samples at locations close to the proposed MSWMF / existing MSW dumping site, indicates possibility of contamination of water bodies in the study area from surface runoff of the organic leachates.

As regards, bacteriological quality, Surface water samples shows Total and faecal contamination in the range of 10-60 and 06-20 CFU/100 ml. E. coli counts were observed in stream passing behind the CMSWMF site, Karmilawada and steam very near to the site. The total and faecal coliforms in the ground water

around the proposed CMSWMF site ranged from 10-86 and 04-26 CFU/100ml respectively. From the results it is clear that the streams passing near to the MSW dumping sites were contaminated with coliforms as compared to the other surface and ground water samples. Even in some ground water samples collected near by the existing MSW dump site also showed the bacteriological contamination. This clearly indicated that the existing MSW dump site is the probable source of contamination.

Land Environment

Keeping in view studying the physical and chemical properties of soil in and round the propose CMSWMF, 20 soil samples were collected as per the standard procedure. The collected soil samples were analyzed for various chemical parameters, viz. electrical conductivity, cation exchange capacity (CEC), exchangeable cations, exchangeable sodium percentage (ESP), nutrients, organic carbon content and heavy metals.

Variation in pH of soil within the study area is in between 4.52-6.95. The soluble salts were determined from soil extract. The soluble salts expressed in terms of electrical conductivity (EC) determined in the soils extracts (1:1) is in the range of 0.042 to 0.547 ds/m. Cation exchange capacity (CEC) of soil samples vary from 1.8 to 24.1 cmol (p+) kg-1 of soil However, a few soils in the study area have CEC levels above 20 cmol (p+) kg-1 of soil, indicating moderate productivity and high adsorptivity, based on its relationship with CEC.

Organic carbon in soil samples of South Goa, vary in the range of 2.77 to 8.56 % and available phosphorous and available potassium varies from 5.45 to 16.20 and 62.10 to 225.0 kg/ha respectively. However, available nitrogen is observed in the range of 215 – 237 kg/ha. The results indicate that the soils are high in organic carbon content and have good fertility level

The landuse / landcover classification as per Classified image of January 8, 2015 indicates 2.9% built-up, 7.5% agriculture, 57.3% forest plantation, 13.5% vegetation, 3.6% scrub land, 8.3% barren land, 1.5% mining and 5.4% water bodies.

Biological Environment

A total of 15 locations were selected from 10 villages for the study on biological aspect. The biological observations were made during at monsoon season. The secondary data related to this region were also obtained from Forest Department.

A total of 46 tree species, 13 shrub species, 8 species of herbs, 8 species of climbers and 5 species of grasses were recorded during post monsoon season. The most dominant trees in this region are *Mangifera indica, Delonix regia* and *Azadirachta indica* While Acacia catechu, *Bombax ceiba, Eucalyptus sps* and *Cocos nucifera* are found in association and phytosociological order. Among shrubs, *Carrisa corandas, Hilicteres isora,* and *Calycopteris floribunda* were the dominants. Among herbs, *Cassia tora, Abutilon indicum* and *Sida rhombifolia* were observed to be dominants while *Ipomea digitata, Calycopteris floribunda*, and *Butea superba* were dominants among the climbers

Mangrove flora within and in the vicinity of study region mostly comprised of 3 species with Avicennia marina as the most dominant. The co-dominant species was Acanthus ilicifolius.

In the study area presence of medicinal plants in terms of quantity is insignificant, as there is very less vegetation cover in the region. However qualitatively out of total plants studied, 18 plant species including 09 trees, 7 shrubs and 2 herbs are of medicinal value.

Large number of domestic mammal's viz., cow, buffaloes, cat, stray dogs, goat etc was always seen in existing MSW dumping site. Monkeys *Maccaca radiata*, *Funambulus palmarum*, and *Felis chaus* were commonly observed within the five kilometers radius from the proposed CMSWMF site. Other than these animals Forest department of Goa, recorded the movements of porcupins, wildboars, jungle cats, foxes, mouse deer and civet cat. In case of avifauna, 18 bird species were recorded in the study area during October 2014 to January 2015. No rare and endangered species of birds was recorded. According to the forest conservator of Goa, seven species of avifauna was freqently observed by them viz., wooly necked stork, whistling teal duck, owls, cattle egrets, greyheron and little egrets.

Goa has many famous National Parks, bird sanctuary and other wildlife sanctuaries include the Bondla, Mollem, Cotigao, Mhadei, Netravali and Mahaveer

wild life sanctuaries along with the Salim Ali bird sanctuary located on the island of Chorao. However none of these are falling under the 10 km vicinity of the proposed CMSWMF site and no other Reserved Forest, National Park or wildlife sanctuary is coming in the study area.

Socio-Economic Environment

The Socio-economic status with respect to demography and Infrastructure Resource Base of the study area comprised of 14 villages in the study area, of which 9 villages are from taluka Sanguem, 3 and 2 villages of talukas Quepem and Salcete of South Goa district respectively was established. As per Cencus 2011, in rural part of the study area, total population of villages is about 20023, while in urban area, total population is 34277. Infrastructure Resource Base with reference to education, medical facility, water supply, post and telegraph, transportation and communication facility, power supply, etc. as per Village Directory CD-2001 of South Goa District is also established to form the basis for prediction of impacts due to proposed CMSWMF.

Prediction of Impacts and Mitigation Measures

Air Environment

Construction Phase: During the construction phase, pollution emission sources shall be distributed throughout the project site and shall fall under the category of area source. The project area is flat, so extensive formation work is not expected during this phase. In addition, due to the confined nature of heavy construction activity during this limited period, tailpipe emissions from construction equipment are assumed to be negligible.

The total area of the site is approximately 1, 13,500 sq m. The entire site will not be simultaneously under heavy construction, with different sections of the site generating SPM in a progressive manner. Thus, it is conservatively assumed that the SPM emission would not be significantly high to warrant any impact prediction.

Operation Phase: In the proposed CMSWMF, biogas generated from biomethanation of organic fraction of MSW after sorting is planned to be used as fuel / feed to the Biogas Genset based Power Plant to generate electric power. The fuel and feed requirement for the above Biogas Genset is 300 m3/hr of biogas. The

expected air emissions from CMSWMF are primarily from the combustion of biogas for power generation. Since the biogas will be purified before combustion, the sulphurous emissions are not expected.

Thus, in the present study, the major source has been considered as the stack attached to the Biogas Genset with the major pollutant identified as NO_x only, being the biogas is devoid of sulphur and particulate, SO_2 and SPM are not considered in prediction exercise. The estimation of emission rates based on rate of fuel consumption and characteristics has been calculated. Also, the meteorological data at the site has been collected during study period. After compilation of data and computing the emission load (g/sec), assessment of impact on ambient air quality using **Industrial Source Complex - Short Term Version 3 (ISCST-3)** model of USEPA for emissions from existing plant have been carried out. Hourly wind speed, wind direction, atmospheric stability, temperature and mixing height data recorded for post-monsoon season at project site are used for predictions. The topography around the the proposed project site represents flat and undulated terrain, vegetation, rural to semi-urban structure industrial area and sea.

Prediction of impact due to proposed project was carried out for computing GLCs on 24 hourly bases in the study area of 5 km radius. The GLCs of NOx were predicted over an area of 20 km x 20km. The GLCs of NOx are computed due to operation of Biogas Genset.

The 24 hourly maximum GLCs of NO_x due to Biogas Genset power plant computed from the model is 25.8 µg/m^3 at 1.14 km in the SW direction. It can be noticed that an increase in NO_x concentration is observed over baseline scenario of max. NO_x concentration of 13.7µg/m^3, which itself is the representation of cumulative of impacts of air emissions from the surrounding residential, commercial and industrial areas, thus aggregating to 40.6 µg/m^3. Though the aggregate value is within stipulated NAAQ Standard, appropriate measures viz. controlled combustion using lox NO_x burners and well designed stacks as per the standards prescribed by the regulatory agencies should be considered at the time of designing and commissioning of facility. Regular monitoring of scrubbing system for purification of biogas provided by the equipment vendors for power generation shall be should be monitored to ascertain for absence of SO_2 emissions.

Apart from the stack emissions the pollutants may also emit by mobile sources (trucks) and fugitive sources viz. land fill area. Around 15-16 truck trips are in operation per day to transport MSW materials into the project site to dispatch compost from the project site and no significant increase in envisaged as the same number of trucks will be operated after commissioning and operating of proposed CSWMF.

Fugitive odors emissions from MSW handling operations and biological processes are the major concerns for all such facilities worldwide. The main sources of fugitive emissions from the CSWMF include minor leaks from the process equipment viz., vessels, valves & pumps and connectors. In the proposed facility it is planned that all the working /storage sheds and biological systems will be provided with adequate number of blowers, vent and ducts to suck the odors emissions and pass it through **biosrubbers** for efficient odor control. Hence, the fugitive emissions of VOCS, and odorous compounds and particulate matter are expected to be negligible.

Noise Environment

Construction phase: Sources of noise emissions are expected from various construction machineries/equipments. General noise levels generated from the operation of equipment and machinery as per literature indicates variations between 94 dBA (concrete pumper) to 124 dBA (Pile driver) at a distance of 1 m, which gets reduced to 70 and 94 dBA respectively at 16 m.

However, since the construction phase is expected to be minor in nature and would be for a limited period, the possibility of all the equipments working together is ruled out, rather it will be used intermittently. Hence, the noise generated at a given time is not anticipated to be exceeding the permissible limit.

Operational Phase: During the operational phase, the major sources of noise are - i) Noise from blowers, shredders, conveyer belts, etc., ii) Noise from (Biogen set) power generator, compressor and other rotating equipments of the power plant and iii) Noise due to vehicular movement for loading / unloading inside the plant premises and on approach roads, national high ways etc.

All the noise producing equipments such as blowers, generator, and compressors would be housed in an acoustic enclosure; hence the ambient noise is not anticipated to be very high. The noise level outside the acoustic enclosure for

different equipments would not exceed the prescribed standards (75 dB(A) at 1 m distance from the equipment).

The increase in noise levels due to vehicular movement for loading / unloading inside the plant premises, on approach roads, national high ways etc., is not anticipated from the proposed CMSWMF, as the same site is presently being used for the disposal of MSW generated in south Goa and the fleet of vehicles deployed on transportation of MSW would remain same. Further, the precautionary measures suggested in EMP would improve upon the present situation.

The main sources of noise generation will be compressors, ID fans, FD fans, blowers, etc. Around 80 workers are expected to work in a single shift, out of which 20 workers would be intermittently exposed to equipments generating noise levels of more than 90 dBA for about 30-60 minutes at a given time during the shift of 8 hrs with due precautions of using PPE. Thus, maintaining their noise-level-exposure and duration will be well within the stipulated standards of OSHA.

Hence, the overall noise impact because of the project activities appears to be insignificant.

Water Environment

Construction Phase: Construction activities for the proposed development can have minor impact on hydrology and water quality of the area as the construction waste will not be leached into ground or any surface water body. Potential impacts on the hydrology and water quality could be as under:

- Soil runoff from the site leading to off-site contamination (particularly during rainy season).
- Improper disposal of construction debris leading to off-site contamination of water resources.
- Unaccounted disposal of domestic wastewater from temporary labour camps.
- Spillage of oil and grease from the vehicles and wastewater stream generated from onsite activities such as vehicles washing, workshop etc.

Operational Phase: The existing raw water requirement for proposed CMSWMF is estimated to be 10.0m^3/d. The processes adopted at CMSWMF are mechanical

segregation of various fractions of MSW, high pressure pulping of organic fraction, biomethanation of pulp and invessel composting of residue. These operations do not require any additional fresh water and hence, the requirement is limited to domestic use. The wastewater generated from the facility is mostly MSW leachate, floor washings and domestic wastewater. The provision to treat the combined wastewater in a separate effluent treatment plant (ETP) equipped with reverse osmosis (RO) system to ensure efficient recycle of water with in the CMSWMF has been made. Wastewaters generated from non-plant use washing and other processes will be treated in ETP and shall be used in floor washing, dust suppression, if required and development of green belt.

Land Environment

Construction Phase: No additional land will be required for proposed CMSWMF, rather the existing site being used for the MSW dumping, since several decades will be used. Due to the unscientific dumping of mixed MSW lead to purification, leachate generation and contaminating the surrounding area. The existing dumping site soil is contaminated with heavy metals, organic matter, and coliform bacteria. The proposed CMSWM facility will eliminate the leachate generation and its subsequent spreading to the surroundings areas. This will ultimately restore the degraded soil quality.

Scientific management and disposal of MSW would positively improve the Health and quality of life as it would eliminate the present unscientific dumping of mixed MSW and associated unhygienic conditions, leading to various vector borne diseases.

The proposed project will be developed on the existing waste disposal site; hence, no change in the land use of the site due to the proposed project is anticipated. With the development of the proposed plant, green belt would be developed and other aesthetic changes would be made to the plant site, thereby creating overall positive impact.

Impact on soil owing to the project construction activity includes soil erosion, compaction, physical and chemical desegregations and pollution of soil in case of

waste discharge on land. The proposed plant will be developed on the existing waste dumping site; hence no negative impact due to the development is anticipated. No significant impact is expected on the soils on and around the site as the entire plant site area will have an underground pipe drainage and runoff facilities.

Operational Phase: During operation phase, compost will be available for agriculture and horticulture purposes and the impact will be beneficial. Treated wastewater, can be safely used for irrigation on the surrounding areas and also for development of plantation and greenbelts on the project premises. Thus, the impact would be favourable one.

Biological Environment

Construction Phase: The existing land cover and physiognomy support plant species typical of habitats and having a low plant diversity and simple structure. Due to commonness of the species recorded and small area of habitats for herbs and shrubs to be lost, potential impacts to flora are considered minor. During the construction stage; removal of understory (shrubs and herbs) will reduce the habitat for a few faunal species. It will be temporary and suitable alternatives are available in nearby areas. The proposed peripheral greenbelt will provide a much better habitat for those species than earlier.

Air, noise and visual disturbance may be generated during the site development that can affect the behaviour of fauna (especially bird, butterflies and other insects, reptiles and very small mammalian species) of the adjacent habitats. However, the disturbance would be confined to the construction period only.

The project authority is neither drawing water from the nearby water resources for construction purposes nor discharging any kind of sewage and debris into it, hence no impact is anticipated from the construction related activities.

Operation Phase: Potential impacts of project operation on terrestrial ecology include long-term air and noise pollution and disturbance generated by area lighting and traffic. Based on the limited fauna community and important flora observed in the buffer zone and the existing land use pattern of the surroundings, potential impacts to fauna from this source are ranked as minimal.

Socio-economic Environment

Positive Impacts: New jobs will be created during construction phase mostly on temporary basis and for skilled and unskilled workers.

Proposed project is expected to contribute to improvement in Health and quality of life in the region because of scientific disposal of MSW, which otherwise is being dumped unscientifically creating unhygienic conditions and vector for various diseases

Besides all essential infrastructures, efforts are being taken by the **Concessionaire (**Project Authority) for encouraging public tours by providing an in-house auditorium / resource centre for information dissemination and displaying the recycling and waste treatment process, gardens, public conveniences and café.

The facility shall not only serve as a tourist attraction, but also as learning centre to create awareness about the positive environmental impact of the solid waste treatment facility in the State of Goa. This would also facilitate image building of the State Govt. with respect to environmental restoration

Negative Impacts: Increased risk of accidents to adjacent neighbourhood and stress on local infrastructure. Change in character of the surrounding community with the influx of population having different culture, trends and lifestyle.

Environmental Management plan

Construction Phase

Environmental impacts during construction phase, will be mainly due to civil works such as site preparation, RCC foundation, construction etc.; material and machinery transportation, fabrication and erection etc.; storage and handling of different kinds of flammable/hazardous materials etc. The construction phase impacts are of temporary nature and localized phenomena, except the permanent change in local landscape and land use pattern at the project site and are expected to reduce gradually on completion of the construction activities. However, they require due consideration with importance during project execution and also wherever applicable detailed protocol / procedures (in case of dismantling of existing

units / infrastructure) as pointed out below shall be followed / implemented to prevent / mitigate adverse impacts and occupational hazards.

The site preparation and plant erection activities during construction phase should be carried out with proper preventive measures for pollution control as well as restoration of dismantled units / infrastructure and proper disposal of existing containments. At the time of civil works for proposed project units, it is necessary to control SPM levels through dust suppression methods.

Project proponent shall take due care to include necessary clauses in respective construction tender / work awards for maintaining strict compliance of occupational health standards for workers during duty period including provision and usage of personal protective equipment (PPE) to mitigate occupational health hazards.

Since the proposed is CMSWMF to be created within the existing land fill area, gases or fumes (CO, CH4, NH_3, H_2S, etc.) due to biomethanation of MSW are likely to be come across, while laying foundations, sufficient mechanical / artificial ventilation shall be provided to protect the health and safety of persons working there.

Efforts should be made to prevent accidental spillage of any oil /grease from construction equipment / maintenance activities. Hazardous materials such as petrol, diesel, lubricating oil, compressed gases, paint and varnishes as also explosives for blasting operations, if required at the construction site shall be stored and handled strictly in accordance with the prevailing safety regulations. Thus, **Concessionaire** authorities need to ascertain these aspects.

The proposed project site is situated in medium seismic zone as per seismic zone map of India. Hence, all critical / major structures shall be designed and constructed as earthquake proof / resistant structures. Utmost precautionary measures / high level of safety measures shall be adhered to while commissioning / test run / startup of individual modules in each phase of proposed CMSWMF.

Exhausts of other equipments used for construction (e.g. generators) will be positioned at a sufficient height to ensure dispersal of exhaust emissions and meet the standards set by CPCB.

Personal protective equipment like earmuffs, helmets covering ears should be provided to the onsite workers, working near noise generating equipment and should be seen that, workers use the protective gadgets regularly.

The project developer should not extract fresh water from any water bodies (surface or groundwater) for the construction phase of the project. Drinking water requirements during the construction phase should be met from packaged water / water transported through tankers to the construction sites. Construction laborers should be provided with adequate quantity of drinking water of potable quality.

During site development necessary precautions will be taken, so that the runoff water from the site gets collected to working pit and if any over flow is, will be diverted to nearby greenbelt / plantation area.

The domestic wastewater generated from temporary toilets used by the work force will be diverted to septic tank followed by soak pit. Therefore, impact on water quality due to proposed unit would be insignificant.

During construction period, there could be clearing of vegetation in order to prepare the site for construction, the top soil from the construction area shall be collected and be stored separately for greenbelt development. A comprehensive green belt program shall be planned to improve the ecological condition of the region.

Project proponents shall ensure provision for necessary basic needs and infrastructure facilities to the families of construction workforce. Workers engaged during construction phase should preferably be provided with temporary housing facilities at planned labor colonies located nearer to project site.

A traffic management scheme should be developed to avoid congestion on the nearby and local roads. The movement of heavy equipments should be done with proper precaution to prevent any accidents on the road. Occupational risk should be minimized at the project site through safety measures. The contractors should also be vigilant to detect workers showing symptoms of communicable diseases. All illness and incidents shall be reported and recorded.

Operation Phase

Necessary control measures will be undertaken at the design stage to meet the statutory requirements and towards minimizing environmental impacts. During project implementation period, special emphasis will be made on measures to minimize lechate / effluent generation and dust control at source. A comprehensive post-project environmental monitoring shall be carried out after commissioning the proposed unit process / unit operations to assess the cumulative impacts. The specific control measures related to air emissions, liquid effluent discharges, noise generation, solid waste disposal etc. due to proposed CMSWMF are recommended as follows:

Air Environment

The main activities from the proposed project which cause air pollution are, dust particulates due to movement of vehicles and road sweepings, temperature & Odour from Compost plant, Odour & Gas generation from secured landfill and combustion products from Biogen sets or flaring of biogas under emergency situations emitted through the respective stacks. The incremental predicted GLCs of major air pollutants viz., NOx due to the proposed activities over the baseline air quality are within stipulated standards of CPCB for residential / rural regions i.e. 80$\mu g/m^3$. However, there will be marginal increase in total NOx emissions. The following measures are recommended to mitigate adverse impacts on air environment:

Regular monitoring of scrubbing system for purification of biogas prior to utilize in Biogas Genset, for power generation for absence of SO2 emissions. Biogas Genset and flare (during emergency condition) shall be operated with minimum excess air (controlled combustion using lox NOx burners), so that fuel combustion is optimized and emission of NOx is minimized. Ambient air quality with respect to PM10, PM2.5, SO2, NOx, Ammonia, VOC"s and CO should be monitored regularly at different sampling stations selected in consultation with Goa UTPCB within the impact zone. The sampling stations should be selected based on the maximum ground level concentration anticipated and keeping maximum stations in the downwind direction and at least one in the upwind direction

Port holes and sampling facilities should be provided at proper location in all the stacks for monitoring of flue gas at regular intervals. A weather monitoring station shall be operated continuously and regular data logging shall be done. Proper moisture, oxygen and C:N ratio shall be maintained to minimize the odour and to maintain adequate temperature in compost plant. Gas management system in secured landfill shall be provided. Green belt shall be provided along the internal roads and plant boundary. To control fugitive emissions of VOCs / Odors, over and above the inbuilt measures of **Bio-Scrubbers** provided by the vendor along with the plant equipment. Inventory of odorous compounds should be maintained and release of such compounds due to leakages should be prevented.

Noise Environment

The noise levels will not exceed 60 dB (A) at the perimeter of the project area. The equipment will be chosen in such a way that the above noise limit is not exceeded. The noise levels at the nearest habitation after proposed CMSWMF will be less than the stipulated standards of CPCB. However, as a good operational procedure, the following generic measures will be implemented in addition to the existing plantation.

The major areas of concern for noise generation shall be adequately addressed by considering it during procurement of the machinery from vendors at project implementation stage. Conduct periodic audiometric tests for employees working close to high noise levels, such as compressors, Biogen sets, the loading and unloading sections, conveyor belts, etc. Provision of Personal Protection Equipments (PPEs) need to be done and their proper usage should be ensured for eardrum protection of the workers as well as visitors. Noise generating sources in the areas of CMSWMF should be monitored regularly. Monitoring of ambient noise levels should also be carried out regularly both inside the facility as well as outside the greenbelts, boundary wall.

Water Environment

The main wastewater generation sources in the proposed project are domestic wastewater, leachate generation from compost plant and secured land fill

area. It is recommended that, top priority should be given to provide a well drainage facility at each process and unit operations for handling MSW to take care of any leachate formed even as rare possibility, during entire operation of CMSWMF to ensure that none of the surface and ground water resources will get contaminated. The performance of ETP should be continuously monitored and any deviation in performance should be corrected on priority, so that the treated effluent would have characteristics of prescribed limits of Goa PCB/CPCB.

Reuse of treated effluent should be attempted to the maximum possible extent. Treated effluent should be used for washing floors etc. The detailed record of raw water intake and wastewater generation from different sources shall be maintained on daily / regular basis.

Storm water drainage system should consists of well-designed network of open surface drains and rainwater harvesting pits along the drains, so that all the storm water is efficiently drained off without any water logging.

Land Environment

Plantation and greenery in and around the CMSWMF may be strengthened and maintained. Effective drainage pattern to avoid contamination by leachates from any point of MSW handling especially during monsoon is mandatory throughout the proposed facility.

A record with respect to quantity, quality and treatment / management of MSW / hazardous waste shall be maintained. All hazardous waste generated shall be segregated as per its category and be stored, handled and disposed off as per hazardous waste (Management & Handling) Rulers, 2003.

Under the Biomedical Waste (BMW) Rules 1998, revised up to the year 2003, the Generators / Occupiers of the medical facility are directly responsible for implementation, developing agency (Concessionaire) has to monitor that the BMW does not get mixed with MSW and shall help the generator in BMW management.

A final landfill cover is usually composed of several layers, each with a specific function. The surface cover system must enhance surface drainage,

minimize infiltration, support vegetation and control the release of landfill gases. The landfill cover to be adopted will depend on the gas management system. As recommended by the MoEF and CPHEEO the final cover system must consist of a vegetative layer supported by a drainage layer over barrier layer and gas vent layer.

Biological Environment

In order to mitigate the impacts due to operation of proposed SWMF, following measures are recommended to mitigate adverse impacts on biological environment. Development of green belt with carefully selected (tolerant to air pollution) plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation / assimilation and for providing food and habitat for local macro and micro fauna. Survival rate of the planted trees should be closely monitored and the trees, which could not survive should be replaced by more tolerant species.

The rainwater harvesting shall be practiced to the maximum possible extent. Treated wastewater should be used for greenbelt development. Provision of land and adequate funds for strengthening of existing as well as additional plantation to create green belt of appropriate width as per CPCB guidelines should be made in the proposed project.

Social awareness programme about the importance of conservation of flora and fauna need to be conducted. The tourists should be strictly warned to avoid throwing of non-degradable waste materials in the project area, so that ecosystem should not get harmed.

Socio-economic Environment

In order to mitigate the adverse impacts likely to arise out of proposed CMSWMF as well as for its smooth initiation and functioning, the following measures are suggested:

- Authority should undertake regular environmental awareness programs to bring forth the beneficial aspects of the projects and environmental management measures being undertaken for improving their Quality of Life

- In order to minimize impact due to traffic conjunction, scheduling for the movement of vehicles should be done in order to avoid peak traffic condition, to the extent possible

- Road side plantation on both side of the approach road to the project site may be undertaken by the project authorities.

Occupational Health Management

There will be routine observation of health as certain sufferings are likely to appear as result of exposure by the workers during operations of various facilities. All the employees shall be required to undergo a medical checkup before joining the facility. Medical checkup will be conducted on regular basis and the health conditions will be monitored. First aid facilities required to attend immediately for meeting emergency situations shall be made available at the facility.

The fire protection system will protect the entire site area from fire hazards happening accidentally. This fire protection system comprises of a ground level water storage tank to store the anticipated requirement of water. One electric motor driven pump and one diesel high pressure pumps will be provided to pump the water to a high pressure header from where the water is distributed to various high pressure hydrants provided at selected locations. Necessary fire hoses terminated with spouts will be kept ready at each hydrant location to facilitate fire fighting. The header also caters to a multi fire system to automatically sprinkle water through sprinklers provided.

Post-Project Monitoring

In order to study the effectiveness of implemented measures suggested in EMP, and to achieve the conditions stipulated in EC for prevention of environmental degradation likely to occur due to proposed developmental activity, it is required to monitor the environmental quality status during construction and operational phase of the project. Thus, the project proponent has to form ‘Environmental Management Cell’ operative right from construction of approach roads and site preparation.

The required instrumentation to facilitate the monitoring of environmental quality with respect to the major environmental components like air, noise, water and land are presented. The environmental quality monitoring such as number of samples, parameters, frequency, duration and associated standards should be followed strictly as specified in the NOC, CFE/CFO and Environmental Clearance etc. by Goa PCB/CPCB and MoEF respectively.

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