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Assessment of Pollution Caused by Garbage Processing Facility, Hadapsar, Pune, India

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Abstract

The assessment of pollution caused by a Garbage Processing Facility (GPF) was conducted. Air monitoring for odorous compounds, VOCs, ammonia and mercaptans was done using sensor based instruments, high and low volume samplers. Leachate water from the GPF and water from nearby bore wells was also analysed. The total amount of solid wastes present at the site at any given time was approximately 3014 tonnes - 3915 tonnes. The gases analyzed such as SO_X, and NO_X were within the NAAQM (National Ambient Air Quality) standards. Odorous gases and VOC's were found to be higher at the GPF and were also present at the downwind site indicating dispersal of these gases from the GPF thereby affecting the neighbours. Methyl mercaptans which gives a strong smell of rotten cabbage was present in a concentration above the odour detection limit of 1 ppb although it was below the PEL (Permissible Exposure Limit) at the time of sampling (PEL as prescribed by OSHA) and was also present in the downwind site. Hence, the GPF is a source of some unwanted gases is affecting the neighbours. The leachate generated had very high BOD and COD and most parameters exceeded the prescribed limit for discharge into the inland surface water, sewers and land disposal as per the Municipal Solid Wastes (Management and Handling) Rules, 2000. It was seen that the GPF was poorly maintained and suggestions were given for proper management of the garbage processing facility to minimize its effect on the environment.

Keywords: GPF, Methyl mercaptans, VOC's, leachate, odorous gases.

Introduction

The Agro waste, Vegetable market waste, Municipal solid waste has great potential as energy source[1-4]. Insufficient knowledge and casual approach towards solid waste management create many problems that can be lead to sever threat to human health[5]. Researcher have found presence of multiple drug resistance bacteria at municipal solid waste dumping site[6.] In uncontrolled dumps, poorly designed and or poorly operated landfills there are problems of leachate generation, gaseous emissions, surface runoff, bad odour, windblown litter and dust, birds, vermin and insects. There are direct or indirect pathways for contaminants or negative effects from uncontrolled disposal sites to human beings especially for those living on or next to dumpsite. These could include contamination in the drinking water supply, airborne emissions, and transfer of pathogens by biological vectors.

Emissions which are typical for dumps and landfills during operation are bad odour, windblown litter and dust. The typical bad odour of landfills is a consequence of unavoidable biological degradation[7]. During waste handling and biological decomposition steps a number of gaseous compounds are generated or removed from the organic matrix and emitted. In fact, composting plants present numerous odour and pollution sources, including reception and materials handling, forced aerated composting, stockpiling, etc. Gaseous emissions in composting facilities are typically constituted by nitrogen-based compounds, sulphur-based compounds and a wide group of compounds dominated by Volatile Organic Compounds (VOCs)[8]. Researchers have reported that volatile compounds emissions are closely related to the composting process: aldehydes, alcohols, carboxylic acids, esters, ketones, Sulfides and terpenes are mainly emitted during the initial acid phase, while in the thermophilic phase ketones, organosulphur-compounds, terpenes and ammonia become predominant[9]. At the laboratory scale, total VOC concentration in exhaust gases from composting processes of different wastes has been also studied and it was concluded that the highest concentrations of VOCs were emitted during the first 48 h of the process[10]. Groups of researcher have studied VOC emissions from the composting process considering the possible negative effects on plant workers and the nearby population[11]. Dimethyl sulfide and dimethyl disulfide together with carbon disulfide and methyl and ethyl mercaptan are very common in organic waste decomposition processes, from aerobic and anaerobic waste treatments. Originating mainly in the microbial degradation of sulphur-containing amino acids found in proteins[12,13]. Mao et al. determined ammonia, amines, dimethyl Sulfide and acetic acid as the responsible for most odours in food waste composting plants compared to numerous VOC[14]. Font et al identified 29 compounds in the odour from this type of waste treatment plants although no correlation attempt between chemical analyses and

odour concentration measurements was reported[8]. The results indicate that the odour concentrations of the kitchen waste composting gases are strongly related to the concentrations of sulphur-containing compounds, hydrogen Sulfide and mercaptans[15]. Trace volatile organic compounds (VOCs) and/or fine aerosols arising as a consequence of volatilization of compounds contained within kitchen wastes and those formed during decomposition have been as significant issue for air pollution and may lead to widespread concerns from local residents near the landfill sites due to the undesirable odours and associated health risks[16-18]. Hecht and Griehl identified the occurrence of the compounds like ammonia, hydrogen Sulfide (H_2S), fatty acids, and aromatic acids by degradation of kitchen waste[19].

Pune is the seventh largest metropolis in India and the second largest in the state of Maharashtra. It is situated at 560 metres (1,837 feet) above sea level on the Deccan plateau at the right bank of the Mutha River[20]. Pune is considered as the cultural capital of Maharashtra. Pune also has many institutions that attract migrants, students and professionals from India, South East Asia, Middle East and Africa. Hence, it also nurtures the large number of hotels and restaurants which results in the generation of about 25% of total MSW generated in the city whereas the total MSW generated per day goes up to 1300 metric tonnes[21]. At the Garbage Processing Facility (GPF) considered in this study windrow composting and vermicomposting is followed where approx. 100 t per day of solid wastes mainly from the Kitchen is dumped. In view of the complaints by the neighbours of the GPF, a study was conducted wherein assessment of the pollution caused by the GPF was carried out.

Methodology

Description of the Facility: The Garbage Processing Facility to be assessed is situated at Plot No. 87, Ramtekdi Industrial Estate, Hadapsar, TPS No.11, Pune- 411028 (18°29'34.12"N Latitude, 73°55'21.14"E Longitude). The layout of the processing facility is given in figure-1. The Garbage Processing Facility (GPF) admeasures an approximate area of 22799.75 Sq. m with a capacity to treat 100 MT of wastes /per day. The site includes concretised area for windrow composting and for the collection of pre-process rejects (4692 m^2). Rest of the non-concretised area is available for vehicular movement (1935 m^2). Drying of windrow composted material including screening is done in the shed area. Material which is partially composted is subjected to Vermicomposting at the site. There is a school having 585 students on its rolls as well as residential complexes situated near the Garbage Processing Facility.

Figure-1
Layout of Garbage Processing Plant, Ramtekdi

Leachate and bore well water analysis: Leachate samples from the facility and the water from the bore wells situated near the facility were collected and analysed see figure-2. A comparison between the leachate samples and bore well water was done to check for any contamination. Parameters analysed were pH, ammonical nitrogen, total kjeldahl nitrogen, biochemical oxygen demand, chemical oxygen demand, metals, chloride and fluoride. These parameters monitored at the garbage processing facility were based on municipal solid wastes (Management and Handling) Rules, 2000.

Air sampling: Air sampling was carried out for SO_X, NO_X, NH_3, PM 10, odorous gases, VOC's and mercaptans. SO_X, NO_x were monitored and PM_{10} using high volume samplers (gravimetric method). Sampling was carried out with an averaging period of 24 hours. The sampling points are shown in figure-3. Instantaneous readings for Volatile Organic Compounds (VOCs) and other group of air pollutants having odour was also taken during morning, afternoon and evening. Sampling of methyl mercaptans which has a typical rotten cabbage smell was also done. These three components were analysed using sensor based instruments (Libelium: Smart Environment Waspmote Plug and Sense model). The odorous gases and ammonia was monitored using resistive sensors and monitoring of VOC's was based on metal oxide/resistive sensors. The gas-Metal oxide sensors are also known as chemiresistors. The detection principle of resistive sensors is based on change of resistance of a thin film upon adsorption of the gas molecules on the surface of a semiconductor solid. Their interactions affect the resistance of the film based on the density of electronic species in the film. It gives instantaneous readings for these compounds. There are no standards for these compounds. However, this method is used for assessing odorous compounds.

Results and Discussion

Leachate Sampling and Assessment: The leachate sample was collected from the leachate collection tank for further analysis. Sampling was done in monsoon and post monsoon. On comparing the leachate quality with the standards given in Municipal Solid Wastes (Management and Handling) Rules, 2000 for different modes of disposal of the leachate, the untreated leachate is unfit for discharge into inland water surface, sewers and also unfit for land disposal. The pH of the leachate was less than 5.5, COD was more than 250 mg/l, BOD was more than 350 mg/l, Ammonical nitrogen (as N) was more than 50 mg/l and Total Kjeldahl nitrogen (as N), was more than 100 mg/l. The concentrations of arsenic, lead and total chromium have increased in leachate samples collected in post monsoon season. The results of leachate analysis are shown in table-1.

Bore well Water Assessment: Water from the bore wells near the GPF were collected and analyzed. One bore well was located at Eagle Burgman which is 316 m from GPF. The other bore well was located at Residential site which is 266 m from GPF. On comparing the results of the parameters analysed from the bore wells with the leachate samples, it was found that the bore well water not contaminated with the leachate see table-2.

Figure-2
Sampling points for the leachate and bore well water

Air Quality Monitoring: Sampling was undertaken during monsoon and post-monsoon period in 2014. Parameters monitored were SO_X, NO_x, and PM_{10} using high volume samplers (gravimetric method). Sampling was carried out with an averaging period of 24 hours. The results of the monitoring are shown in the table-3. The analysis of ambient air at the site show that the concentration of gases is well within the National Ambient Air Quality Monitoring (NAAQM) standards. The maximum concentration of SO_x and NO_x were complying with the NAAQM standards of 80µg/m^3 each. For H_2S, there is no NAAQM standard but as per OSHA standard, permissible exposure limit of H_2S is 20 ppm.

Solid Waste Characterisation: Solid waste characterization of the incoming waste was carried onsite in monsoon and post monsoon 2014. Physical characterisation of solid waste was carried out on site. 100 kg of unsegregated solid waste is weighed and then characterised into organic waste, plastic waste, glass, aluminium foil and paper. The wastes received at the site comprised mainly of 87% of organic wastes and the rest consisting of plastic (7 %), glass (3%), aluminium foil (1.5 %) and paper (1.5%).

NH_3, VOCs and odour producing compounds monitoring: Instantaneous readings for Volatile Organic Compounds (VOCs) and other group of air pollutants having odour was also taken during morning, afternoon and evenings. Sampling of methyl mercaptans was also done. These three components were analysed using sensor based mechanisms. Odorous gases comprises of gases such as toluene ($C_6H_5CH_3$), hydrogen Sulfide (H_2S). VOC's (volatile organic compounds) comprises of gases such as hydrocarbons, chlorinated hydrocarbons, aromatic hydrocarbons, aromatic alcohols, aliphatic alcohols, terpenes, glycols, aldehydes, esters and acids. The results are mentioned in the table-4.

Analysis of Methyl mercaptans: Methyl mercaptans were sampled and analysed in the post monsoon season at the above mentioned sites. The maximum average concentration was found to be 37 ppb at the Garbage Processing Unit and minimum concentration was 6 ppb at Control site. The concentration of methyl mercaptans found at the facility does not exceed the permissible limit of 10 ppm (OSHA). However, concentration exceeds the odour threshold of 1 ppb which explains the odour as sensed. At such concentrations mercaptans are mild irritants and can cause headache and nausea but are not detrimental to health.

Figure-3
Google Map Showing the GPF (Garbage Processing Facility), Down-wind site (KB wines) and the location of the school

Table-1
Assessment of the Leachate Generated

Parameters Unit(mg/l) except pH	**Leachate collected in monsoon**	**Leachate Collected in post monsoon**	**Std. as per Municipal Solid Wastes (Management and Handling) Rules, 2000**		
			Mode of Disposal		
			Inland surface water	**Public Sewers**	**Land Disposal**
pH	4.8	4.9	5.5 to 9.0	5.5 to 9.0	5.5 to9.0
Ammonical Nitrogen	710	809	50	50	-
Total Kjeldahl Nitrogen	1826	1119	100	-	-
BOD (3days at 27^0C)	22861	21867	30	350	100
COD	73296	61568	250	-	-
Arsenic	0.05	0.17	0.2	0.2	0.2
Mercury	0.01	0.007	0.01	0.01	-
Lead	0.05	0.09	0.1	1	-
Cadmium	0.005	0.001	2	1	-
Total Chromium	0.06	0.36	2	2	-
Zinc	11.43	5.6	5	15	-
Nickel	1.74	0.46	3	3	-
Chloride	3343	3065	1000	1000	600

Table-2
Assessment of Bore well Water

Parameters, Unit(mg/l) except pH	**Bore well 1 (Industrial) Location : At Eagle Burgman which is 316 m from GPF**	**Bore well 2 (Residential) Location : At Residential site which is 266 m from GPF**	**Leachate Location : At GPF**
pH	7.3	7.7	4.8-5.2
Ammonical nitrogen (as N)	<0.5	<0.5	710-809
Total Kjeldahl nitrogen (as N)	<0.5	<0.5	1119-1826
BOD (3 days at 27^0C)	< 10.0	< 10.0	21867-22861
COD	< 10.0	< 10.0	61568-73296
Arsenic (as As),	<0.001	0.004	0.05-0.17
Mercury(as Hg)	<0.001	<0.001	0.007-0.01
Lead (as Pb)	0.0022	0.03	0.05-0.09
Cadmium (as Cd),	<0.001	<0.001	0.001-0.005
Total Chromium (as Cr)	0.013	0.03	0.06-0.36
Zinc (as Zn)	0.03	<0.001	5.6-11.43
Nickel (as Ni)	<0.001	<0.001	0.46-1.74
Chloride (as Cl)	61.3	31.58	3065-3343

Table-3
Ambient Air Monitoring

Sites	**Day**	**Monsoon**			**Post- monsoon**		
		SOx ($\mu g/m^3$)	NOx ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	SOx ($\mu g/m^3$)	NOx ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)
A	Day 1	6.1	56	95	6.5	6	98
C		7	48	74	12.3	16	80
D		6.4	47	24	6.0	7	32
A	Day 2	7.2	55	82	8.3	6	89
C		6	36	71	12.3	34	82
D		6.2	25	40	6.0	6	51
A	Day 3	6.9	20	86	7.3	8	92
C		7.2	10	93	12.0	19	95
D		7.1	7	47	6.0	3	53
A	Day 4	6.4	23	65	14.0	53	72
C		6.8	9	61	8.0	16	71
D		7.8	6	19	6.0	6	25
A	Day 5	7.3	12	81	8.0	16	89
C		7	8	78	14.0	53	85
D		6.6	7	58	10.5	55	74

A-GPF/source, B-Downwind site, C- Control site, D- School. H_2S-Non detectable

Table-4
NH $_3$, Odorous compounds and VOC monitoring

Day	**Day 1**					**Day 2**				
Sites	A	B	C	D	E	A	B	C	D	E
NH_3 (µg/m^3)	399	305	244	279	262	405	198	206	219	156
Group of odorous compounds (ppm)	384	307	178	287	237	609	116	93	77	80
VOC (µg/m^3)	369	261	224	308	275	429	267	236	289	260
Day	Day3					Day 4				
Sites	A	B	C	D	E	A	B	C	D	E
NH_3 (µg/m^3)	532	619	435	541	576	510	365	405	338	374
Group of odorous Compounds (ppm)	711	117	121	180	101	738	133	98	82	80
VOC (µg/m^3)	505	249	356	269	267	458	264	256	279	244
Day	Day 5					Day6				
Sites	A	B	C	D	E	A	B	C	D	E
NH_3 (µg/m^3)	616	527	332	340	426	481	381	346	291	327
Group of odorous Compounds (ppm)	447	137	73	87	92	435	198	111	100	82
VOC (µg/m^3)	343	285	271	304	298	410	283	264	287	290
Day	Day 7					Day 8				
Sites	A	B	C	D	E	A	B	C	D	E
NH_3 (µg/m^3)	664	616	481	534	482	359	353	354	458	381
Group of odorous Compounds (ppm)	460	230	91	116	114	470	194	396	180	166
VOC (µg/m^3)	368	322	294	314	297	432	328	387	358	332

A-GPF/source, *B-Downwind site*, C- Control site, D- School. H_2S-Non detectable

As per the observations, Windrow composting and Vermicomposting of municipal solid wastes was followed at the site. After sorting of solid wastes, the biodegradable material was subjected to windrow composting. The composting period is of 45 days. The heaps were turned once in seven days. The compost formed was taken away by the farmers and the partially composted material was subjected to vermicomposting. The odour was sensed from the composting windrows and where screening was carried out post windrow composting. The amount of solid wastes received at the site per day was 77-100 tonnes, 87% of this was biodegradable and remains at the site for approximately 45 days of windrow composting period. Therefore, the total amount of solid wastes present at the site at any given time as windrows is approximately 3014 - 3915 ton. The leachate generated had very high BOD and COD and most parameters exceed the prescribed limit for discharge into the inland surface water, sewers and land disposal as per the Municipal Solid Wastes (Management and Handling) Rules, 2000. The leachate was not treated before it was discharged. The site was infested with flies and at the time of sampling mosquito larvae were observed at the site. There were plenty of dogs and scavenging birds. The sorters were poorly equipped as

per safety concerns namely the workers were not wearing appropriate gloves and masks while segregating the waste and proper footwear was not used by them. Odour was sensed at the Garbage Processing Facility which increased as we moved towards the windrows. Outside the facility the odour was sensed in the downwind site. During the sampling period the wind direction was towards KB Wines which is approximately 119 meters away. The people at KB wines complained of odour issues and headaches. At the school the students and teachers also complained of headaches and odour during other times but during the sampling period the wind direction was not towards the school and hence, no odour was sensed. Most of the gases analyzed SO_X, NO_X and PM-10 were within the NAAQM standards, Odorous gases and VOC's were found to be higher at the GPF. Methyl mercaptans which gives a strong smell repulsive smell of rotten cabbage was present in a concentration above the odour detection limit of 1 ppb although it was below the PEL (Permissible Exposure Limit) at the time of sampling (PEL as prescribed by OSHA).

Conclusion

The mismanagement of GPF has led to increase in the environmental pollutants. The leachate quality has exceeded the standard limits for discharge but the water from the nearby bore wells was not found to be contaminated. The leachate should be treated before discharge. The ambient air quality of the GPF (SO_x, $NO_{x,,}$ PM10) and nearby areas follow National Ambient Air Quality Monitoring Program (NAAQM) standards given by Central Pollution Control Board (CPCB). Facility was a source of VOCs which travelled to the downwind side. For prevention of pollution caused by GPF, regular monitoring of the concerned gases needs to be done. Although at the time of sampling the concentration of methyl mercaptans was within the PEL (Permissible Exposure Limit) given by OSHA (Occupational Safety and Health Association), but its concentration was above the Odour Detection Limit and is giving a repulsive odour at the sites. There is a possibility of higher emissions of methyl mercaptans in the air under warmer atmospheric conditions. The VOCs and Methyl mercaptans emitted by the facility was most probably the cause of headache and nausea of people residing the downwind area Measures should be taken to further eliminate the odour such as the use of bio-filters. The solid waste sorters should be properly equipped ensuring their health safety. Green belt development in the buffer zone may help at least partially to mitigate / obfuscate the odour. Green belts are used to form a surface capable of absorbing and forming sinks for odorous gases. Leaves with their vast area in a tree crown, sorbs pollutants on their surface, thus effectively reduce their concentrations in the ambient air and source emissions.

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