

MONITORING OF MUNICIPAL SOLID WASTE MANAGEMENT FACILITIES AND ASSESSMENT OF AIRBORNE MICROBIAL EMISSION IN SELECTED LOCATIONS OF KERALA AND KARNATAKA

**Project report on Annual Action Plan (AAP),
Scheme VI (25)**



**CENRAL POLLUTION CONTROL BOARD, ZONAL
OFFICE, BENGALURU**

Cover photograph: A view of MSW facility in South Panamana village in Ottapalam Municipality, Palakkad district, Kerala.

Photograph by Deepesh V.

Monitoring of municipal solid waste management facilities and assessment of airborne microbial emission in selected locations of Kerala and Karnataka, Project report on annual action plan (AAP), Scheme VI (25)

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Monitoring and inspection of Municipal Solid Waste (MSW) management facilities in Kerala.

Five MSW management facilities in Kerala were selected randomly and monitored. All selected facilities were in towns/ municipalities and were small facilities to cater the waste management of town municipalities (Table: 01). Waste management facilities in Muvattupuzha municipality (Mudavoor), Attingal Municipality (Attingal), Ottapalam Municipality (South Panamana), Malappuram Municipality (Pulliyattummal) and Taliparamba Municipality (Karimbam) were inspected and airborne microbial emissions from these facilities were monitored.

Table: 01-List of MSW facilities monitored in Kerala

MSW facility	Municipality	District	Unit operations
Mudavoor	Muvattupuzha	Ernakulam	Partial segregation, composting & disposal.
Attingal	Attingal	Thiruvananthapuram	Partial segregation, Biogas generation, vermicomposting, composting & disposal.
South Panamana	Ottapalam	Palakkad	Partial segregation, composting & disposal.
Pulliyattummal	Malappuram	Malappuram	Partial segregation, composting & disposal.
Karimbam	Taliparamba	Kannur	Partial segregation, composting & disposal.

Sampling methodology

Airborne microbial emissions were monitored using a microbial air sampler (Sampl'air PRO, AES, France) based on solid impaction technology. In solid impaction method, agar plates of specific media were used to collect the airborne microbial flora when a specific volume of air (up to 1 m³ of air) is aspirated through the sampler. Bioaerosol particles collected over the agar media surface will develop into individual colonies on incubation and will be enumerated.

This method will assess only the viable airborne microorganisms present in the sampling location. During sampling, meteorological conditions/parameters such as relative humidity, temperature, wind speed, wind direction etc were collected using a portable weather tracker. Pre-prepared sterile petri plates (90 mm) containing specific agar media were mounted on the sampler head with their top lid removed and covered by a stainless steel suction head containing several perforations. Sampler was programmed to sample a pre determined volume of air (100-1000 L) depending on the likely microbial load in the sampling location. During sampling (100 L/min) bioaerosols are impacted on the solid agar media in the petri plate and on incubation, microbial density is counted as colony forming units (CFU) and results expressed per 1000 L of air.

Selection of sampling points

Sampling locations were determined after considering site specific parameters and characteristics. Airborne microorganisms/ bioaerosols were sampled at specific locations within the MSW management sites, based on the topography, site layout, activity and predominant wind patterns. General sampling locations were in the up wind and downwind directions, in the peripheries and surrounding areas (within a radius of 1 km). Usual monitoring location placement is based on the site specific activity, topology and general wind patterns at the time of monitoring. For locations within congested area, sampling points were selected based on the proximity to waste which is the likely source of airborne microbes.

Microbiological media

Specific media were used to sample specific microbial entities relevant to this study (Table: 02). Agar media as shown in table were used to assess the specific microbial load in the air samples sampled in the MSW management sites. All media were prepared aseptically, packed in clean rooms and taken to the field in an ice box.

Table: 02-Details of the media used and its specific organisms

<i>Microbial media</i>	<i>Target organisms</i>
Soybean casein digest agar (SCDA)	General heterotrophic airborne bacteria
Potato dextrose agar (PDA)	General airborne fungi
Sabauraud chloramphenicol agar (SCA)	General airborne yeast and molds
Mac Conkey agar	Enterobacteriaceae/ <i>E. coli</i>
Salmonella Shigella agar (SS)	<i>Salmonella spp.</i> , & <i>Shigella spp.</i>
Enterococcus agar	Enterococci group
Cetrimide agar	<i>Pseudomonas spp.</i>
Mannitol salt agar (MSA)	<i>Staphylococci spp.</i>
Sheep blood agar (SBA)	Haemolytic microorganisms
MRSA agar	Methicillin resistant <i>Staphylococcus aureus</i>

Mudavoor, Muvatupuzha Municipality, Ernakulum, Kerala.

Mudavoor MSW facility is located in Valakkuzhi, a residential area adjacent to the traditional agricultural area called Kadathy fields. The facility is a small establishment with a small segregation/ processing shed without any scientific landfills, weighing scale and other structures for processing compost or recyclables. At the time of inspection, the facility was not processing any waste due to public protest and partial segregation of waste and unscientific disposal were observed. A few truck loads of waste (approximately 6 tons/ day) was manually segregated and salvageable items were collected and rest of the waste was indiscriminately dumped all over the places. The extent of discriminated waste dumping can be observed from the satellite imagery (Figure: 01). At the time of inspection, the facility was not having any compound wall or fencing to prevent stray animals.

Airborne microbial pollution was assessed at the MSW facility using solid impaction based air sampler (Sampl Air Pro, AES, France) and weather details were recorded using pocket weather tracker (Kestrel weather tracker, USA). Following sampling locations were selected for assessing airborne microbial emissions from the facility (Figure: 02).

Figure: 01: Mudavoor MSW site, Satellite imagery of waste disposal (Source: Google Maps)



Location L-1MM

This sampling point was outside the entrance near to the residential area. The point will be 100m away from the garbage dumps inside the facility. Since predominant wind direction was towards the residential area across the entrance, this site was selected as the downwind location.

Location L-2MM

The sampling point was on the middle of the facility where the wastes are dumped. Since the location is close to several dumps, this point was treated as 'near source'. Airborne microbial densities will be higher in such location due to wind action on open garbage dumps.

Figure: 02-MSW facility at Mudavoor, Muvattupuzha Municipality, Kerala.



Defunct composting shed



Sampling at Location L-1MM

Attingal Municipality, Thiruvananthapuram, Kerala.

The MSW facility of Attingal Municipality is located in the heart of Attingal town on Kaduvayil road. The facility was established on a small area with several waste processing sheds, underground biogas plants for leachate and waste disposal area for plastics/ rejects/ inert materials. Attingal Municipality had implemented door to door collection system covering all urban population and collects 57% of waste which amounts to 8 tons per day. Around 5 to 6 tons of waste generated from markets and other sources were processed in the facility. Though, majority of the waste collected is segregated at source, in reality segregation is not proper with lot of plastic inert materials in the processed waste. The facility also installed a plastic shredder to process plastic inert materials. The leachate is processed by anaerobic digestion and two biogas tanks were provided. However, biogas generated was not properly utilized by the facility. Though the facility was having aerobic composting, vermicomposting and biogas plants in a small area, the characteristic odour of waste processing was not that conspicuous. Storage of plastic waste and other rejects were not scientific (Figure: 03). At the time of inspection, indiscriminate dumping of plastics/ rejects was observed in the open space (Figure: 04) where the compound wall was breached and no stray animals were observed inside the facility premises.

Figure: 03-MSW facility at Attingal Municipality, Thiruvananthapuram, Kerala.



Vermicomposting shed



Refuse dumping area

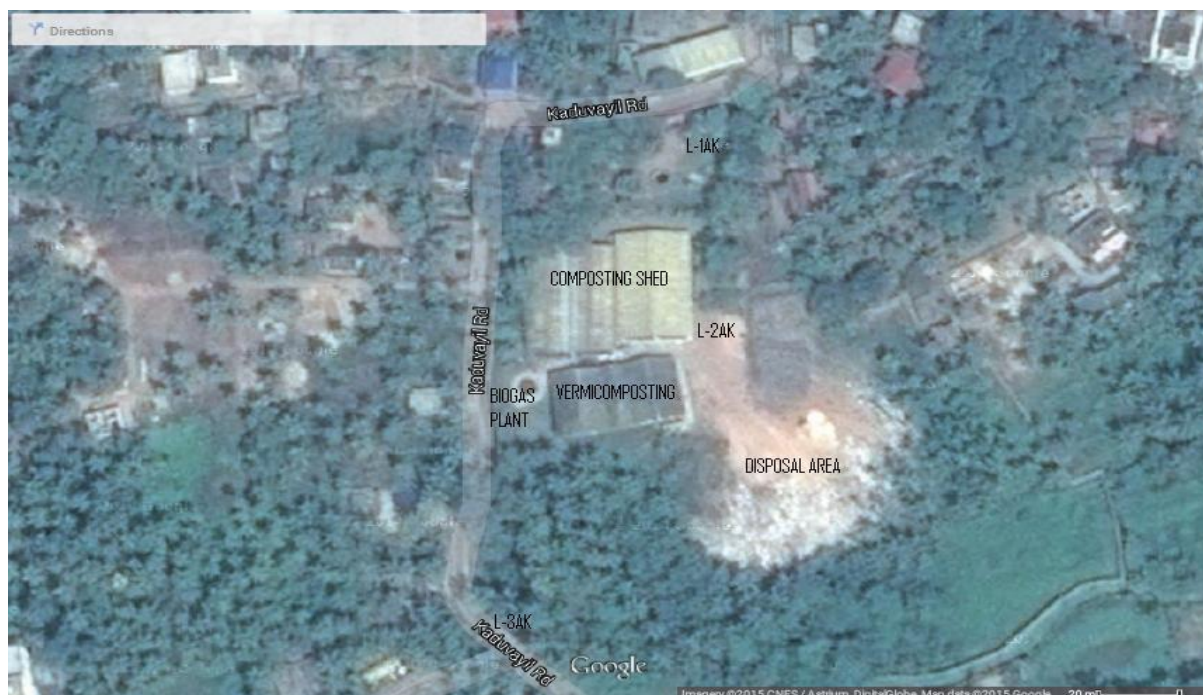


Composting sheds



Sampling at Location L-2AK

Figure: 04-Attingal MSW site: Satellite imagery of facility and waste disposal (Source: Google Maps)



Following sampling locations were selected for assessing airborne microbial emissions from the facility (Figure: 04).

Location L-1AK

Sampling was carried out at the entrance near to security cabin, which is 50m away from the compost processing sheds. This point was selected because predominant wind direction at the facility was towards this area and hence it was considered a downwind location.

Location L-2AK

This location was near an open spot in close proximity to composting and vermicomposting sheds. Since it is close to the likely sources of airborne microbial emissions, it was considered as a 'near source' sampling point.

Location L-3AK

Location 3 was outside the facility premises, 100m away from the compost sheds. Monitoring was done on the road side near to a pond and there were several residences nearby. The location was monitored to assess the airborne microbial densities of upwind location.

South Panamanna, Ottapalam Municipality, Palakkad, Kerala.

Ottapalam town is a prominent town in Palakkad district of Kerala. It is situated on the bank of Bharathapuzha (River Nila) and is 35 km from Palakkad. The MSW facility is in South Panamanna village and approximately 9 tons of waste is processed daily. The facility houses a processing shed with waste grinding machine and a plastic shredding unit which is yet to be operational. There were no scientific landfills or disposal facilities and plastic wastes were found disposed all over the facility. Manual segregation of salvageable waste was done and inert materials are disposed in the nearby fields. Reclaimed old waste dumps were observed inside the facility. At the time of inspection, it was observed that the waste processing and composting were not proper. There were several small/ large heaps of grinded waste all over the place and matured heaps were not further processed. Inert/ rejects after compost processing were indiscriminately dumped all over the place. The plastic shredding unit in the facility was not operated due to lack of approval from the authorities. Overall upkeep and maintenance was pathetic at this facility and the disposed wastes were encroaching the adjoining agriculture fields (Figure: 05). The facility was not having any compound wall and few stray animals were observed during the inspection. Following sampling locations were selected for assessing airborne microbial emissions from the facility (Figure: 06).

Location L-10K

Sampling carried out near to the entrance of the facility. There several heaps of plastic wastes all around the place and predominant wind direction was from this point to the waste/ compost processing shed.

Figure: 05-MSW facility at South Panamanna, Ottapalam Municipality, Palakkad, Kerala.



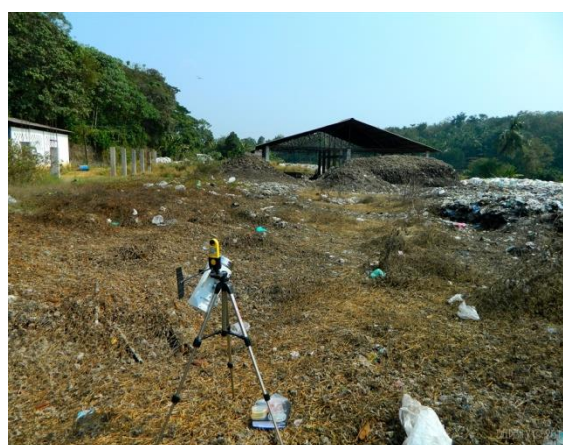
Refuse dumping area



Sampling at Location L-10K



Sampling at Location L-20K



Sampling at Location L-30K

Figure: 06- South Panaman MSW site, Ottapalam- Satelite imagery (Source: Google Maps)



Location L-20K

Airborne microbial emission samples were taken from the compost/ waste processing shed. At the time of assessment there were no waste/ compost processing activities.

Location L-30K

Another set of samples were taken from the periphery of the facility on top of old, reclaimed waste dumps. The wind directions suggested this location as up wind sampling point. There were rubber tree plantations bordering the periphery of the facility.

Pulliyattummal, Malappuram Municipality, Malappuram, Kerala.

The waste management facility of Malappuram Municipality is situated at Pulliyattummal, near Inkel Park for small & medium enterprises, Panakkad. The small facility is in an isolated place and caters to few truck loads of waste from Malappuram town. The small process shed houses a waste grinding unit and composting area (Figure: 07). Inert and other rejects were randomly deposited all over the place and during the inspection it was observed that many of such refuse heaps were burned. The facility process waste by composting and

rejects are dumped in open space. A very small quantity of waste was processed here and method adopted for disposing refuse were not scientific.

Figure: 07- Pulliyattummal, Malappuram MSW site, Satellite imagery (Source: Google Maps)



Figure: 08-MSW facility at Pulliyattummal, Malappuram Municipality, Malappuram, Kerala



Sampling at Location L-1MK



Sampling at Location L-2MK

Following sampling locations were selected for assessing airborne microbial emissions from the facility (Figure: 08).

Location L-1MK

Near source sampling point inside the processing shed. During monitoring there was no waste processing activities but there were heaps of processed waste kept for curing.

Location L-2MK

Near partially burned refuse / unsegregated waste dumps. Wind direction suggested that the location is an downwind sampling point.

Location L-3MK

Near the boundary wall, behind the processing shed and was taken as the upwind monitoring location. There were old waste/ refuse heaps nearby.

Karimbam, Taliparamba Municipality, Kannur, Kerala.

MSW waste management facility is located near Karimbam. The facility was established on a narrow strip of land with only one process shed housing process and segregation area (Figure: 09). At the time of inspection unsegregated waste was maintained as large heaps inside the process area. There were several dumps of inert materials all over the place and stray animals were freely roaming inside the process area. It was noted that semi processed waste along with inert materials were given free to rubber planters as soil conditioner/ for mulching and due to the plastic/ inert materials planters were not interested to take the processed waste. The facility handles the MSW from Taliparamba town and the facility was not at all equipped to process the MSW. Following sampling locations were selected for assessing airborne microbial emissions from the facility (Figure: 10).

Location L-1TK

Sampling was carried out in the upwind location near to the boundary wall, which is hardly 20m from the process/ compost shed.

Location L-2TK

Samples collected from the upwind location (100m away from the compost shed), which is on top of old reclaimed waste dumps in the adjacent plot.

Location L-3TK

Samples collected inside the waste/ compost processing shed near to the compost processing screen.

Figure: 09- Karimbam MSW site: Satellite imagery of MSW facility (Source: Google Maps)



Figure: 10-MSW facility at Karimbam, Taliparamaba Municipality, Kannur, Kerala



Sampling at Location L-3TK



Sampling at Location L-2TK

Observations

All the MSW facilities visited in Kerala were operating not in accordance of the MSW rules (2000). There observed gross violation of rules in terms of infrastructure and operation. In all the facilities there was no proper segregation of waste, waste processing was not as per the stipulated guidelines and rules. The most striking reality is the indiscriminate dumping of non-biodegradable wastes such as plastics/ refuses and inert materials. It was a common sight of huge piles of plastic waste dumped in the periphery of the facility and often it was observed that these piles of waste encroached the surrounding agriculture fields.

Table: 03-Airborne Microbial Emissions from all MSW facilities monitored

Monitoring location	sampling location code	<i>Salmonella</i> spp.	<i>Shigella</i> spp.	<i>E.coli</i>	<i>Enterococci</i>	<i>Pseudomonas</i> spp.	<i>General Fungi</i>	<i>Heterotrophic bacteria</i>	<i>Yeasts / Molds</i>	<i>Haemolytic bacteria</i>	<i>Staphylococcus aureus</i>	<i>MRSA</i>
Mudavoor MSW	L-1MK	0	10	10	10	0	640	510	710	50	40	0
	L-1MK	0	30	50	20	10	890	640	930	70	220	0
Attingal MSW	L-1AK	0	0	30	0	0	380	420	710	0	140	0
	L-2AK	0	0	0	0	0	610	590	640	10	270	0
	L-3AK	0	20	40	0	0	880	730	720	0	0	0
Ottapalam MSW	L-1OK	0	0	0	10	0	870	290	460	70	50	0
	L-2OK	0	0	20	0	0	790	720	690	40	30	0
	L-3OK	0	0	40	0	20	410	460	580	0	220	0
Malappuram MSW	L-1MK	0	40	20	0	10	2020	380	1520	120	20	0
	L-2MK	0	10	80	10	0	290	390	280	340	160	50
	L-3MK	0	290	160	10	70	510	860	390	720	0	0
Taliparamba MSW	L-1TK	0	0	20	0	0	920	1610	320	230	30	0
	L-2TK	0	0	0	0	0	170	280	200	80	0	0
	L-3TK	0	0	10	0	0	290	320	560	60	10	0
Reference	L-1WK	0	10	30	0	10	860	640	1140	30	10	0
Control	L-1VK	0	0	0	0	0	142	84	184	0	0	0
All results in CFU/m3 of air sampled												

Airborne microbial emission studies (Table: 03) suggested that the waste handling and unscientific storage of waste do contaminate the ambient atmosphere with airborne microbial pollutants. Indicator microorganism, opportunistic pathogens like *Staphylococcus*

aureus and haemolytic bacteria were present in all facilities monitored. Presence of *Pseudomonas spp.*, *MRSA*, *Enterococci* were limited to few facilities.

However *Salmonella spp.* was not detected in any of the locations monitored. Highest densities of airborne *Shigella spp.*, *MRSA*, Haemolytic bacteria & *Pseudomonas spp.* was observed in the Malappuram MSW facility. Highest density of general heterotrophic bacteria, fungi, yeasts and moulds were also observed in the samples collected from this facility. In control location only airborne bacteria, fungi, yeasts & moulds were only detected. The airborne microbial density profiles suggests that the waste handling in all the locations monitored emits considerable amount of microbial pollutants.

Monitoring and inspection of Municipal Solid Waste (MSW) management facilities in Karnataka.

MONITORING LOCATIONS

MSW management sites like solid waste processing/composting sites, garbage segregation site, large MSW landfill sites and other MSW facilities were monitored in this study. Place of monitoring was selected on random basis and assessment was done at 3 locations in Hassan, Udupi and Mangalore.

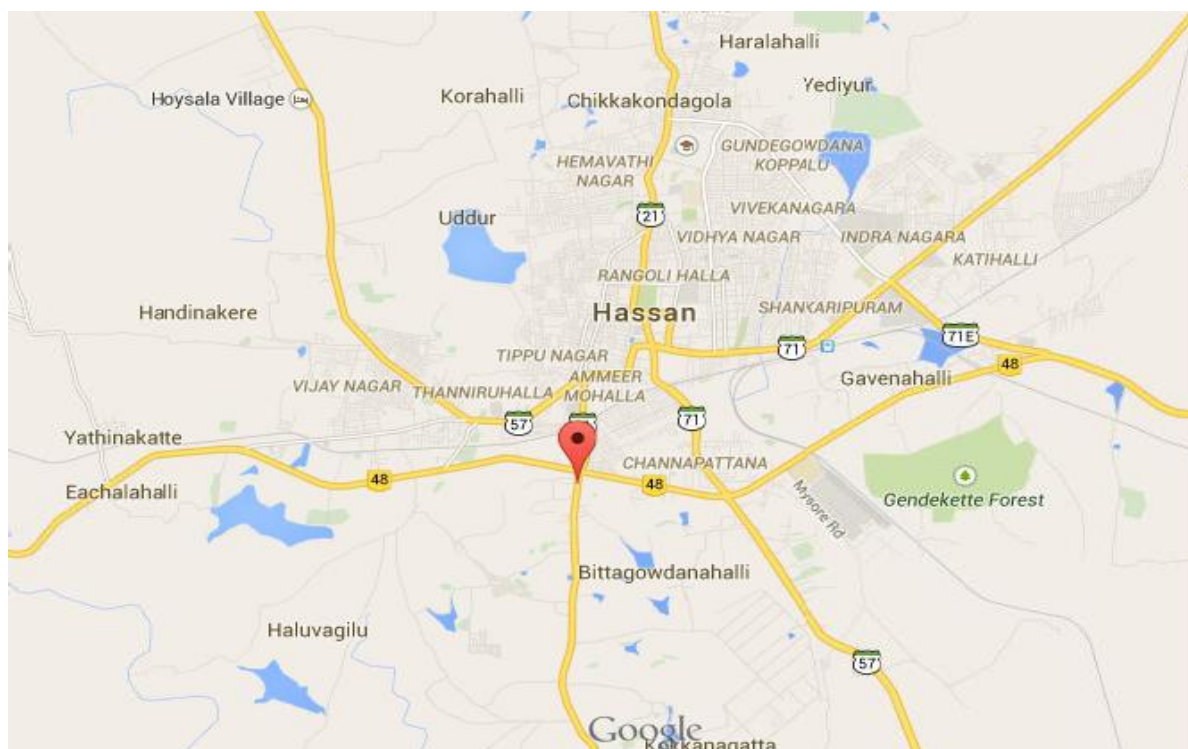
Monitoring locations

<i>Sl no.</i>	<i>Place of monitoring</i>	<i>Nature of MSW facility</i>	<i>Managed by</i>
1	Gorur Road, Hassan	MSW landfill site	CMC Hassan
2	Alevoor, Udupi	MSW processing site	CMC Udupi
3	Pachchanady, Mangalore	MSW processing site	M/s IL & FS Ltd

HASSAN

The city of Hassan is situated between 12° 0' 13" and 13° 0' 33" North latitude and 75° 0' 33" and 76° 0' 38" East longitudes. It is connected by the National highway 48. It has an area of 6814 km². The present population of the city is 1, 55,006 according to the 2011 census data. The amount of solid waste generated per day is 62 tonnes per day. The agency responsible for the handling of MSW is the City Municipal Council (CMC) Hassan. About 50-55 tonnes of solid waste are collected per day. The method of disposal followed here is that of land filling. The landfill site is located on Gorur Road in Hassan. It is basically a dumpsite very near to the main road, with cases of waste overflowing on the roads. The site is not properly operated with heaps of waste is strewn all over the place. MSW from the city is brought by trucks and is dumped here. Also, the site is very near to human dwelling. A very small amount of the waste, about 10-12 tonnes undergoes composting. But this facility is not in use most of the time due to space constraints.

Monitoring location 1: Gorur Road, Hassan, Karnataka (Source: Google Maps)



Sampling Location 1

This location is near the composting facility which is adjacent to the dumping site at a distance of around 50 m from the dump site. The compost prepared is stored in temporary sheds at this location.

Sampling Location 2

This location is at the site where the collected MSW is dumped. It is along the path way where trucks carrying MSW move about. The dumpsite is situated next to the RMC yard of Hassan.

Sampling Location 3

This sampling location is situated at about 100 m away from the dumpsite. At this location, many shops are situated and a lot of human activity takes place.

MSW facility at Gorur Road, Hassan, Karnataka



Location -1, Hassan



Location -2, Hassan



Location -3, Hassan



Proposed area for MSW site at Hassan



Defunct composting facility at Hassan



Accumulated wastes in Hassan facility

UDUPI

The city of Udupi is situated between 13° 03' North latitudes and 74° 07' East longitudes. It is connected by National highway 17. It has an area of 68.23 km². The city of Udupi has a population of 1, 25,230 according to the 2011 census data. The amount of solid waste generated is 56 tonnes per day. The City Municipal Council (CMC) of Udupi is the agency responsible for the management of MSW generated in Udupi. About 50-55 tonnes of solid waste are collected per day. The method of disposal followed is land filling. The MSW

processing site is situated at a distance of about 12 km from Udupi at a place known as Alevoor. The area of the processing site is about 22 acres. The waste collected in the city is transported to the dumpsite via trucks. The collected waste is manually segregated for recyclable wastes such as plastic bottles. A microbial culture is applied to the waste and then the waste undergoes composting.

Monitoring location 2: Alevoor, Udupi, Karnataka (Source: Google Maps)



Sampling Location 1

The first sampling location in the MSW processing site is at the landfill site. This site is about 100 m away from the entrance of the processing site. At this site, segregated waste is dumped in the form of heaps. A separate leachate collection facility is made which is adjacent to the landfill site.

Sampling Location 2

The second sampling location is at the segregation site. This site is situated near the entrance of the MSW site. The fresh waste collected and transported by trucks is dumped here. Recyclable materials such as plastic, paper etc is segregated manually. Also, microbial culture is applied to the waste on a daily basis for a period of 4 weeks.

Sampling Location 3

The third sampling location is situated about 500 m away from the MSW processing site.

MSW facility at Alevoor, Udupi, Karnataka



MSW dumpsite, Udupi



Location -1, Udupi



Location -2, Udupi



Location -3, Udupi



Segregated waste at Udupi MSW facility



Waste piles inside composting shed

MANGALORE

The city of Mangalore is situated between 12° 0' 87" North latitudes and 74° 0' 88" East longitudes. It is connected by National highway 48. It has an area of 200 km². The city of Mangalore has a population of 4,99,497 according to the 2011 census data. The amount of waste being generated is about 250 tonnes per day. The agency responsible for the handling of MSW generated is M/s Unique Waste Processing Company Limited, IL & FS Environment.

The amount of waste collected is 225 tonnes per day. The method of disposal followed is that of composting and also vermicomposting. The MSW site is situated at about 10 km from the city at a place known as Pachchanady. The area of the site is about 35 acres. The waste collected in the city is transported to the dumpsite via trucks. The waste is screened and segregated using mechanical sieves and screeners. Then, the waste is applied with a microbial culture and is aerobically composted in about 4-5 weeks. Vermicomposting is also being followed here.

Sampling Location 1

The first sampling location was that at the segregation site. Here, wastes are segregated based on their sizes using standard sieves. Segregation takes place by placing the wastes on a moving belt with a magnetic belt which separates the wastes based on their sizes.

Sampling Location 2

The next sampling location was adjacent to the segregation site. Here, microbial culture is applied to the segregated waste. This is added in order to reduce the size of the heap and also this culture helps in decomposing the organic wastes.

Sampling Location 3

The next location is the dumpsite where fresh waste transported by trucks is dumped until it is taken for segregation. There was a volleyball court situated adjacent to the dumpsite.

Sampling Location 4

The next sampling was done near the entrance of the processing site. This location is near to the administrative office. It falls in the pathway where the movement of trucks loaded with MSW takes place.

MSW facility at Pachchanady, Mangalore, Karnataka



Location -1, Mangalore



Location -2, Mangalore



Application of microbial culture to wastes



Vermicomposting shed



Location -3, Mangalore



Compost processing facility

Sampling Location 5

The last sampling was done in front of SDM Mangala Jyothi School which is situated at a distance of 500 m from the processing site. This location is very near to human dwelling and also with the presence of vehicular movement.

Monitoring location 3: Pachchanady, Mangalore, Karnataka (Source: Google Maps)



Details of sampling locations

Sl no.	Date	Location code	Location description	Remarks
MSW Dumping site, Gorur Road, Hassan				
1	29-10-2014	L-1 H	Composting site	Adjacent to dumping site
2	29-10-2014	L-2 H	Dumping site	Adjacent to RMC yard
3	29-10-2014	L-3 H	near human dwelling	100 m away from the dumping site
MSW Processing site, Alevoor, Udupi				
1	30-10-2014	L-1 U	Landfill site	segregated wastes are land filled and covered with soil
2	30-10-2014	L-2 U	Segregation site	Fresh waste is dumped here
3	30-10-2014	L-3 U	near human dwelling	500 m away from the MSW site
MSW Processing site, Kudupu village, Pachchanady, Mangalore				
1	30-10-2014	L-1 M	Segregation site	wastes are segregated based on their sizes
2	30-10-2014	L-2 M	site at which microbial culture is applied	microbial culture is added to reduce the size of the waste heap and also to prepare compost
3	30-10-2014	L-3 M	fresh waste dump site	Adjacent to volleyball court
4	30-10-2014	L-4 M	entrance of the processing site	movement of trucks containing waste and adjacent to the office
5	30-10-2014	L-5 M	near SDM Mangala Jyothi School	500 m away from the MSW site

Weather conditions during monitoring

Sl no.	Location code	Temperature (°C)	Relative humidity (%)	Wind speed (m/s)	Elevation (m)	GPS Coordinates
MSW Dumping site, Gorur Road, Hassan						
1	L-1 H	27.4	57.2	0.6	905	N 12° 59.777' E 076°05.609'
2	L-2 H	31.6	47.1	0.4	912	N 12° 59.777' E 076°05.610'
3	L-3 H	33.9	47.1	0	961	N 12° 59.984' E 076°05.631'
MSW Dumping site, Alevoor, Udupi						
1	L-1 U	33.5	63.4	0.7	72	N 13° 18.748' E 074°48.241'
2	L-2 U	34.2	55.8	0.4	67	N 13° 18.787' E 074°48.164'
3	L-3 U	32.8	59.3	0.7	76	N 13° 18.950' E 074°47.843'
MSW Dumping site, Kudupu village, Pachchanady, Mangalore						
1	L-1 M	28.7	76.6	0.7	108	N 12° 54.799' E 074°53.459'
2	L-2 M	29.5	72.9	0	99	N 12° 54.861' E 074°53.383'
3	L-3 M	28.5	80	0.8	96	N 12° 54.888' E 074°53.417'
4	L-4 M	29.4	72.9	0	86	N 12° 54.781' E 074°53.447'
5	L-5 M	27.4	80.5	0.5	77	N 12° 54.624' E 074°53.657'

RESULTS

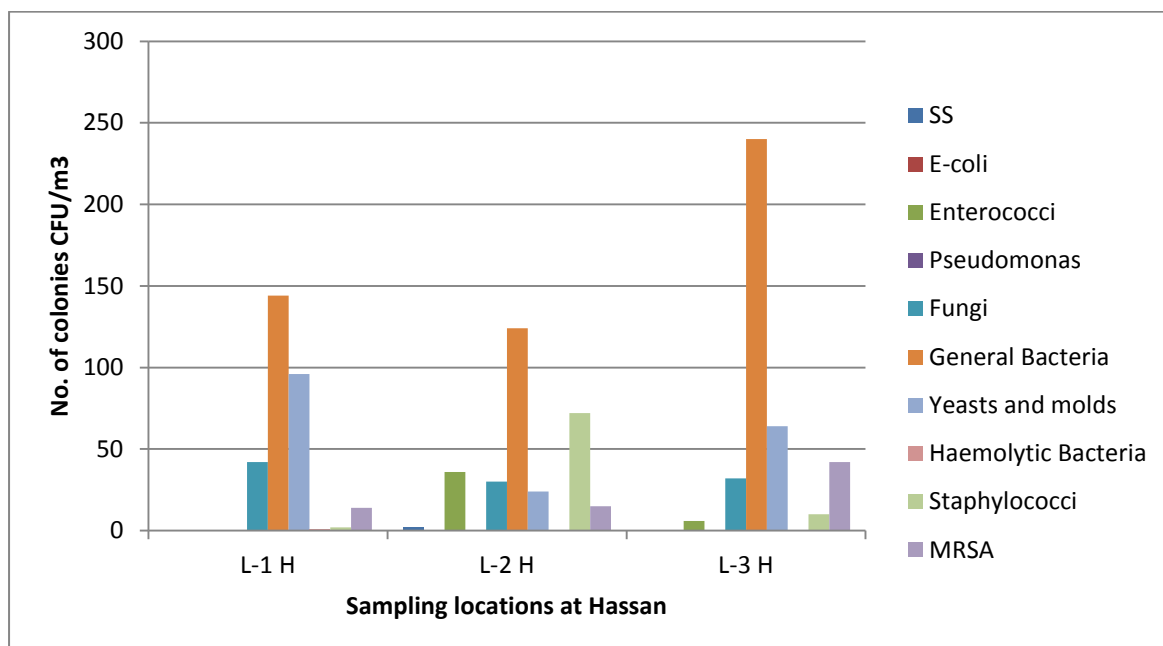
The results of the airborne microbial colonies at MSW sites are tabulated in tables 6, 7 and 8. The enumerations of the monitored organisms are divided into bacterial and fungal colonies. Based on the graphs plotted, the following results were obtained:

Airborne viable microorganisms (CFU/m³) monitored at Gorur Road MSW site, Hassan, Karnataka.

Location	Media									
	SSA	MCA	EA	CA	PDA	SCDA	SCA	SBA	MSA	MRSA

L-1 H	0	0	0	0	42	144	96	1	2	14
L-2 H	2	0	36	0	30	124	24	0	72	15
L-3 H	0	0	6	0	32	240	64	0	10	42

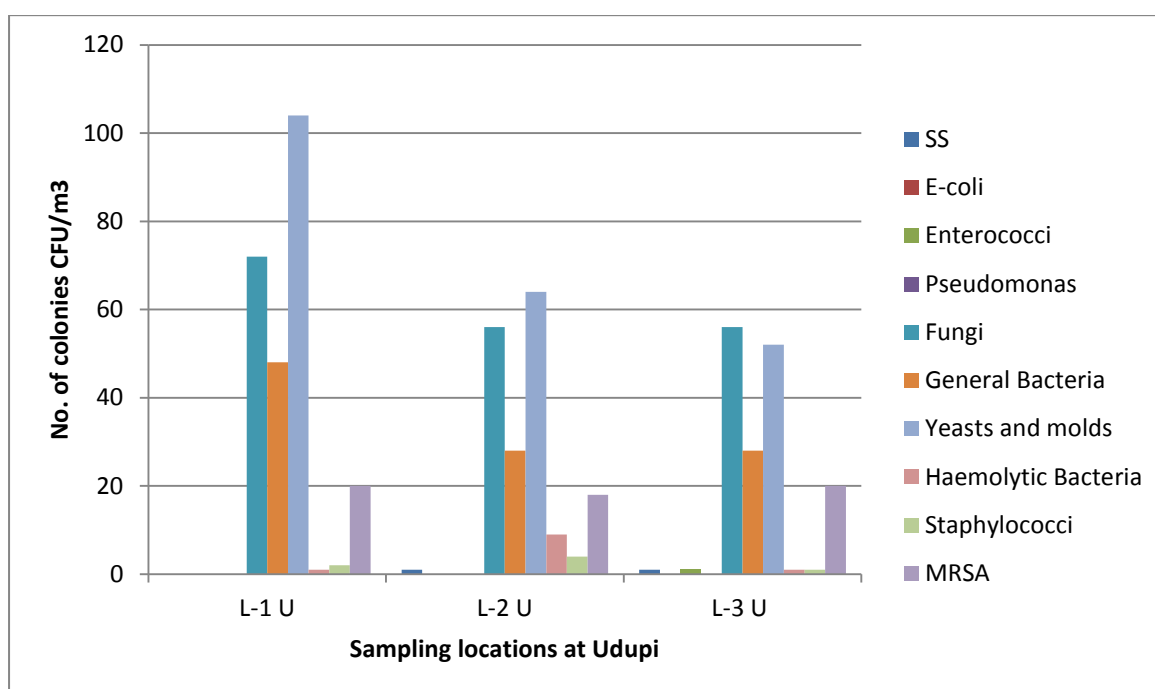
Airborne microbial densities at all locations in Hassan



Airborne viable microorganisms (CFU/m³) monitored at Alevoor MSW site, Udupi, Karnataka.

Location	Media									
	SSA	MCA	EA	CA	PDA	SCDA	SCA	SBA	MSA	MRSA
L-1 U	0	0	0	0	112	48	104	1	2	20
L-2 U	1	0	0	0	72	28	64	9	4	18
L-3 U	1	0	1	0	56	28	52	1	1	20

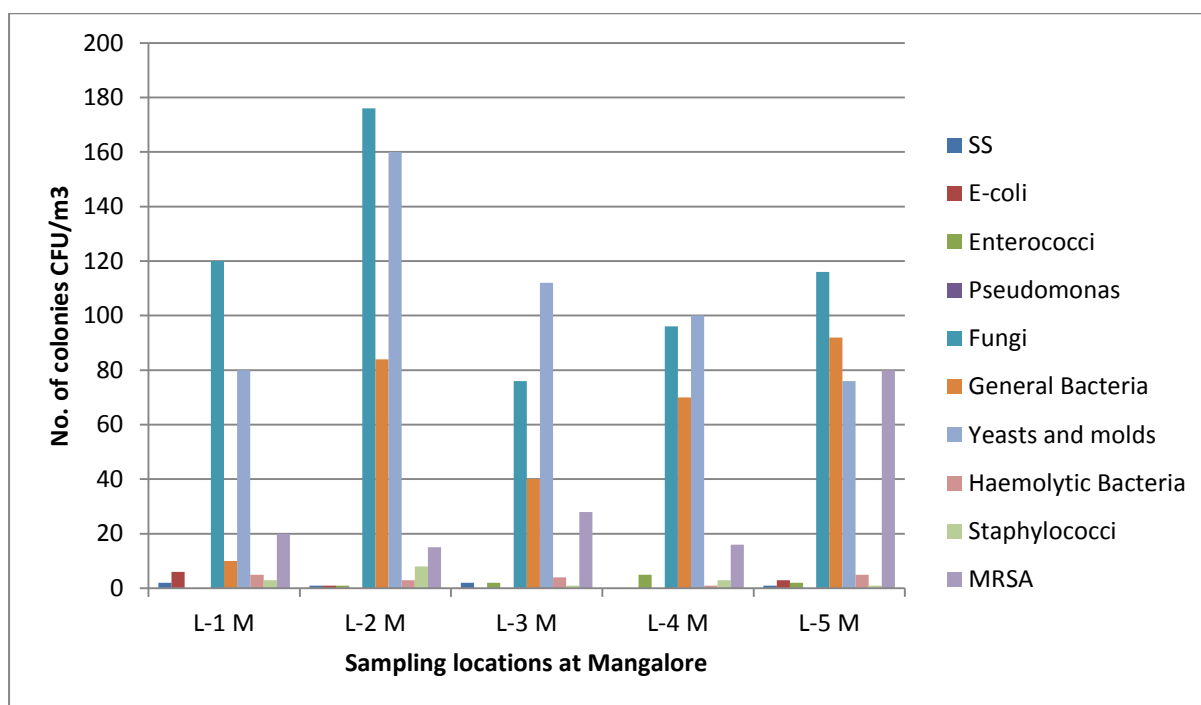
Airborne microbial densities at all locations in Udupi



Airborne viable microorganisms (CFU/m³) monitored at Pachchanady MSW site Mangalore, Karnataka.

Location	Media									
	SSA	MCA	EA	CA	PDA	SCDA	SCA	SBA	MSA	MRSA
L-1 M	2	6	0	0	120	10	80	5	3	20
L-2 M	1	1	1	0	176	84	160	3	8	15
L-3 M	2	0	2	0	76	40	112	4	1	28
L-4 M	0	0	5	0	96	70	100	1	3	16
L-5 M	1	3	2	0	116	92	76	5	1	80

Airborne microbial densities at all locations in Mangalore



Observations

General bacteria were isolated on the SCDA plate. The bacterial colonies obtained were in the range of 10 to 240 CFU/m³. The highest bacterial count was found at Hassan, followed by Mangalore and Udupi. This is based on the fact that the growth of these microorganisms depends on various factors such as media, pH, temperature, incubation period, carbon source etc. *Enterobacteriaceae* members such as *Salmonella* and *Shigella* were isolated on the SSA plate. These organisms were found at all the locations monitored at Mangalore, compared to Udupi and Hassan. Presence of these organisms indicates the amount of

sanitary wastes present in the dump site. *E. coli* were isolated on the MacConkey plate. These organisms were observed in Mangalore, but could not be isolated Udupi and Hassan. This may be attributed to the disposal of raw human faecal discharges and other human wastes at the waste dump site. *Enterococci* were isolated on the enterococci agar plate. The colonies obtained were in the range of 1 to 36 CFU/m³. The highest count was found at Hassan followed by Mangalore and Udupi. This gives an indication that the presence of *Enterococci* which is predominantly from animal origin is dispersed to air due to unscientific handling of waste. Haemolytic bacteria were isolated on the SBA plate. The highest number of colonies was found at Udupi followed by Mangalore and Hassan. The colonies were isolated at all the sampling locations in Mangalore, with a gradual decrease in number in Udupi followed by Hassan. The reason for the occurrence of these organisms can be attributed to animal origin. *Staphylococcus aureus* was isolated on the MSA plate. The number of colonies obtained ranged from 1 to 72 CFU/m³. The highest number of colonies was found at Hassan, followed by Mangalore and Udupi. The isolation of the organism indicates that the waste dumped at these places have a potential to cause skin infections. Methicillin Resistant *Staphylococcus aureus* were isolated on the MRSA plates. The colonies obtained were in the range of 14 to 80 CFU/m³. The highest number of colonies was found at Mangalore, followed by Hassan and Udupi. MRSA is known to cause severe skin infections and is resistant to many antibiotics such as methicillin, amoxicillin, penicillin etc. the colonies were found in large numbers which is alarming. These organisms infect those with a weak immune system. General fungi are isolated on the PDA plate. The colonies obtained were in the range of 30 to 180 CFU/m³. The highest number of colonies was found in Mangalore followed by Udupi and Hassan. Presence of yeast and yeast like fungi in the air may be a potential health hazard to humans, as they cause epidermal and systematic mycoses and allergic diseases. Pathogenic yeasts and molds are isolated on the SCA plate. The colonies obtained were in the range of 24 to 160 CFU/m³. The highest number of colonies was found at Mangalore, followed by Udupi and Hassan. This is due to the fact that microbes harbouring on waste can be dispersed in the air due to physical handling of MSW like screening, sieving, heaping, turning etc. *Pseudomonas spp.* is isolated on the Cetrimide plate. In this study, *Pseudomonas* could not be detected from air samples monitored at all the locations.

The results of this study have provided an insight on the effect of different methods of handling waste on the generation and release of airborne microorganisms. The results also illustrate the quantum of airborne microorganisms in a complex, variable and open air environment such as a waste processing site.

CONCLUSIONS

The objective of this study was to measure bioaerosol levels from MSW handling facilities at Hassan, Udupi and Mangalore. The study monitored three MSW handling sites at the selected locations. Airborne microbial emissions were monitored using a portable microbial air sampler (Sampl'air PRO, AES, France) based on solid impaction technology. In solid impaction method, agar plates of specific media were used to collect the airborne microbial flora when a specific volume of air (up to 1 m³) is aspirated through the sampler. Bioaerosol particles collected over the agar media surface were enumerated after incubation. Ten different microbial media were used during the sampling. After sampling, the plates were incubated at 28°C for 48 hrs. Aspirated microbial plates were enumerated using a digital colony counter and the results were corrected using correction factor and extrapolated to 1m³ of air sampled.

From the study it can be concluded that MSW management and handling invariably emits airborne microbial particles and the magnitude of emission depends on the handling. The study indicates that in open dumps, emissions are relatively less when compared to MSW processing sites as it involves more intense handling of waste such as segregation, sorting, sieving, loading, heaping etc. Wind patterns and local meteorological conditions influence the dispersion patterns of bioaerosol emissions to the surrounding environment. Presence of indicator microorganisms and also other opportunistic pathogens is also a clear indication of absence of storing and clearing waste in a scientific manner.

Based on the study the following conclusions were derived:

- The study shows that MSW sites had deteriorated microbiological quality of air in its surroundings.

- The commonly isolated air borne microorganisms were general heterotrophic bacteria, fungi, yeasts and molds, enterococci spp., haemolytic bacteria, staphylococci spp., and MRSA
- Overall bacterial density was highest in Hassan, followed by Mangalore and then Udupi. The reason for this being the resistance of the organisms to hostile conditions.
- Fungi and yeasts and molds were highest in Mangalore, followed by Udupi and lastly Hassan.
- MRSA colonies were highest in Mangalore, followed by Hassan and then Udupi.
- The locations L-5 M, L-3 U and L-3 H were the sampling locations situated near to human dwellings. There was a significant increase in the densities of general bacteria and MRSA at these locations.
- Haemolytic bacteria being pathogenic were isolated at all the three locations. The highest numbers of colonies were found at Mangalore, followed by Udupi and lastly Hassan.
- Though general bacteria were high in all the locations, none of the sites showed the presence of *Pseudomonas aeruginosa*.