JUSTICE A V RAMAKRISHNA PILLAI
(Former Judge, High Court of Kerala)
CHAIRMAN

State Level Monitoring Committe, Kerala
(An authority constituted by the
National Green Tribunal)
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13.03.2023

Sir,

Kindly see the appended report in O.A. Nos.442/2013(SZ), 20/2017(SZ) and 276/2017(SZ) regarding the fire incident occurred on 02.03.2023 in the Solid Waste dumping yard at Brahmapuram in Ernakulam District.

The same may kindly be placed before the Hon'ble Tribunal for consideration and orders.

Yours Sincerely,

JUSTICE A.V.RAMAKRISHNA PILLAI,
(Chairman, SLMC, KERALA)

To
The Registrar,
National Green Tribunal, Southern Zone Bench,
Kalas Mahal, Kamarajar Salai, PWD Estate,
Chepauk, Triplicane, Chennai, Tamil Nadu-600005.

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,
SOUTHERN ZONE, CHENNAI

O.A. Nos.442/2013(SZ), 20/2017(SZ) and 276/2017(SZ)

REPORT

PRESENTED BY JUSTICE A.V.RAMAKRISHNA PILLAI
(FORMER JUDGE, HIGH COURT OF KERALA)
CHAIRMAN, STATE LEVEL MONITORING COMMITTEE, KERALA
(FOR AND ON BEHALF OF THE AFORESAID COMMITTEE)
REGARDING THE FIRE INCIDENT OCCURED ON 02.03.2023 IN THE SOLID WASTE DUMPING YARD AT BRAHMAPURAM IN ERNAKULAM DISTRICT

PRESENTED ON : 13.03.2023

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REPORT

It is with deep angst and feeling of distress I place this report on a major a fire, broke out by the evening of 02.03.2023 in the Solid Waste Dumping Yard at Brahmapuram in Ernakulam District. The magnitude of the recent incident is far higher than that of the fire incidents occurred during the previous years.

This report may be read along with my previous reports dated 22.2.2020 in OA.No.514/2019 and connected cases O.A.Nos. 533/2018, 534/2018 and 535/2018 before the Principal Bench of National Green Tribunal, the copy of which was forwarded to this Tribunal also on the same day. The subsequent reports dated 28.7.2021 and 24.1.2022 in O.A.Nos.442/2013(SZ), 20/2017(SZ) and 276/2917(SZ) may also be referred to.

O.A.No.514/2019 before the Principal Bench was registered suo motu on the basis of my report dated 23.2.2019 regarding a major fire break out on 22.2.2019.

The recent fire at the solid waste dumping yard at Brahmapuram was at about 3 P.M on Thursday, the 2nd March 2023. It appears that adequate and effective fire controlling measures could not be taken during that day. By Friday morning giant plumes of toxic smoke billowed from the yard was seen spread over different parts of Kochi City as well as adjacent areas beyond the outskirts of Kochi. The inhabitants within the limits of Kochi Corporation were seriously affected by the toxic smoke emanating from the yard. The solid waste dumped unscientifically in the yard appeared to be completely ravaged by the fire.

Fire Engines from Thrikkakkara, Eloor, Thrippunithura, Gandhi Nagar and Aluva units as well as Helicopters from Indian Navy were deployed to put out the fire. During the first day of operation no demonstrable results could be achieved for the reasons stated in the later part of this report. However, hundreds of fire fighters including Navy personal battled consistently to bring the blaze that has gone on four days under control, though the bellowing of the smoke continued even on the 9th day of March 2023.

The personal from the Fire and Rescue Department as well as from the Navy have done a commendable job to bring the flames under control and they deserve special appreciation for their service.

The History of the Waste Dumping Yard at Brahmapuram:

The Brahmapuram Yard having a total extent of about 110 Acres of land, is within the local limits of a Village on the outskirts of Kochi Municipal Corporation at Ernakulum District. Basically it is a wet land by the side of river Kadambrayar which is identified by the Central Pollution Control Board as one of the polluted river stretches in India.

The non-degradable waste including plastics now seen in the yard is a collection from June 2007 onwards. In the year 1998, the Municipal Corporation of Kochi purchased wet land having an extent 37.33 acres at Brahmapuram. Till that time the solid waste from the limits of Kochi Corporation was being taken to Cheranalloor in Ernakulam District. However, due to public protest the Kochi Municipal Corporation had to stop dumping waste at Cheranalloor and had to find an alternate site for waste dumping. Thus, they started dumping of waste in a marshy land under the control of Navy at Willington Island. However, in the year 2006 permission was withdrawn by the Indian Navy due to various reasons. Later, on the strength of an Order passed by the Hon'ble High Court of Kerala in June 2007, Kochi Corporation started dumping at the present yard at Brahmapuram.

Though initially there was a protest from the nearby local body dumping started under Police protection. In the year 2010 more extend of land was acquired for the yard. As no effective scientific waste disposal was carried out all most all portions of the yard are filled with waste materials (Degradable as well as Non-degradable) paving way to repeated fire incidents. Though Brahmapuram Yard is under the management and control of Kochi Municipal Corporation, Solid Waste from Five adjoining Municipalites and Two Panchayaths is being brought to Brahmapuram site.

Sequence of Events:

It is said that there were fire incidents in the yard in the years 2009, 2010, 2013, 2014 and 2015. However, t*he first fire incident since the formation of State Level Monitoring Committee (SLMC for short) in the yard was on 22.2.2019.*

After the fire incident on 22.2.2019, a special meeting of the SLMC was convened on 1st March, 2019 at Government Guest House, Ernakulam. The Mayor, Kochi Municipal Corporation; the MLAs of Ernakulam, Kunnathunadu and Thrikkakara; were invited to attend the meeting. However, the MLAs of Ernakulam and Kunnathunadu remained absent. The issue relating to Brahmapurm plant was discussed in detail.

At the end of meeting, the Secretary, Kochi Municipal Corporation as well as the Member Secretary, Kerala State Pollution Control Board were directed to submit reports in writing before the SLMC in its next meeting so that remedial measures could be suggested. The importance of taking adequate measures for solid waste disposal, controlling air and water pollution by taking public into confidence was also stressed in the meeting.

Simultaneously, a study was caused to be conducted by the Environmental Technology Division, CSIR – National Institute for Interdisciplinary Science & Technology (CSIR-NIIST), Thiruvananthapuram, Kerala, on the emission of dioxins during the fire break out on 22.2.2019.

In the report submitted by them in April 2019, it is observed as under:

"It may also be noted that several such fire breakouts incidents had occurred in the past and is still occurring intermittently at Brahmapuram as well as at several small, medium and large scale MSW open dump yards across the state and in the country. The findings of the studies conducted by CSIR-NIIST clearly indicate that alarmingly high levels of dioxins are getting emitted from such anthropogenic activities across the country. The possible health consequences of human exposure to these highly toxic POPs are a matter of great concern.

4. Summary and Recommendation

The waste dump at Brahmapuram caught fire during early hours of 23/2/2019 and the fire was brought under control on 25/2/2019. CSIR-NIIST conducted the dioxin emission monitoring during 24 – 25th February 2019.

The major findings of the study are:

1. *The average dioxin levels observed in ambient air was found to be 10.3 pg TEQ/m3 at a distance of 50m to 100m from the fire. The observed levels are 50 and 10 times higher than reference and field blank data.*
2. *The dioxins generated are predominantly captured in residual ash. This was observed also in our previous laboratory studies. The Brahmapuram residue ash has dioxin content 159 ng TEQ/kg of ash. It is comparable with the results obtained from the Burnhut studies (101.9 and 136.9 ng TEQ/kg of waste) conducted at CSIT-NIIST.*
3. *The quantity of dioxins emitted during the fire at Brahmapuram is 72 milligram Toxicity equivalence, using emission factors determined in burn-hut studies.*

- *It is essential to establish modern solid waste treatment plants and clear the dump yards of wastes by 'bio-mining' to separate combustible and inert material. The contaminated ash separated during bio-mining should be removed to sanitary landfill.*
- *Given the widespread burning of waste and dump yard fires, analysis of dioxins in animal origin food samples such as milk, egg, meat and in human milk is recommended."*

In the next meeting of the SLMC held at Thiruvananthapuram on 15.3.2019, the issue was considered as Agenda No.3. The extract of the minutes on the agenda item is given below:

> "*The SLMC expressed displeasure over the action taken by the Corporation of Kochi, in disposing of legacy waste. It was suggested by the Additional Chief Secretary, LSGD, that the legacy waste be disposed of part by part by means of bio mining as per the guidelines of CPCB within 15 days ably assisted by a technical expert thereby addressing the present environmental issues till the Waste to Energy plant comes into existence. The Member Secretary, SLMC & KSPCB assured all technical support to Kochi Corporation in this regard. On a specific quarry to the Secretary, Corporation of Kochi as to whether there is any permanent fire fighting mechanism at the site to prevent unexpected fire incidents, he could not give a cogent answer. Therefore, it was suggested by the Additional Chief Secretary, LSGD, that measures such as providing overhead water storage tank of adequate capacity, heavy duty pump sets and fire belt for handling fire hazards, be taken. It was also directed that only segregated waste be taken to the plant. The need to resort to bio mining was also stressed by the Additional Chief Secretary, LSGD."*
>
> Other specific directions were also given to the Corporation.

The issue again came up for consideration before the meeting of the SLMC held on 6th April 2019 where in the following observations were made.

> "*The SLMC expressed displeasure over the action taken by the Kochi Corporation in disposing of legacy waste and the failure of the Corporation in complying with the directions of the SLMC in the previous meeting. The Secretary, Kochi Corporation informed that they have provided 1500 m road in the solid waste dump yard for the easy access of fire engines.*"

It was also resolved in the meeting a local inspection of the Brahmapuran site be conducted during the 2nd week of May 2019.

Accordingly, I along with the Chairman, KSPCB visited the yard on 21st May 2019. The inspection revealed that the statements made by the Corporation authorities in the previous meeting regarding the remedial measures taken were not fully correct. The following were noted in the inspection.

Waste Collection

It was seen that source separated wastes materials are received at Brahmapuram. (However, the legacy waste dumped at the yard was in un-segregated condition which indicated that the arrival of waste to the yard in segregated condition, was of recent origin) Trucks containing the waste materials were seen weighed and recorded. Inspection of the registers showed the following details for 19-5-2019.

19-5-2019	tonnes	Collection Area	Collected by
Wet waste	51.9	Kochi Corp. circle 11-21	Contractor
	6.1	Kochi Corp. circle 1-10	Contractor
	16.5		Corporation
	22.7	Municipality	
TOTAL WET WASTE	97.2		
Dry waste	14.2		Corporation

The collection contractors were seen paid Rs.1500/- per tonne delivered.
The plant operator contractor was seen paid Rs.550/- per tonne.

Treatment of waste

Wet waste was seen heaped to allow composting. This was carried out in the sheds that still have roofs. There was no windrow formation plan. Windrow size was not being followed. Here it is apt to note that it is impossible to follow a scientific windrow pattern or windrow turning pattern as the entire premises has been overfilled. After degradation for a period of time, the material is screened through 40mm, 16mm and 4 mm trommel screens to produce city compost. The trommel screens provided in the plant by Kochi Corporation, were said to be not working. The plant operations contractor has installed 1 trommel screen. Therefore, the quantity of compost produced was very low, compared to the quantity of waste collected at the yard. As there was no off-take of the city compost produced, it was seen stockpiled.

As far as dry waste is concerned, the quantity of dry waste collected was very low and it was seen dumped without further processing.

Odour

The plant had extreme odour, so much so, that it was difficult to carry out the inspection. The workers were not provided with protection equipments.

Leach ate

At the time of inspection leach ate was flowing from the area where initial food waste degradation is taking place. Structured drains are not available on the composting platform for collection of leach ate. The Corporation has constructed garland drains around the composting sheds for collection of leach ate. However, efficient interception of leach ate is not possible. The floors were not properly sloped into the new drains. Major portion of the drains were not covered with slabs. Most of the slabs provided were broken or having holes, indicating that those slabs were used somewhere else by the Corporation.

There was a leach ate pit filled with leach ate allowing percolation and overflow to the nearby areas including river Kadambrayar. No sheet piling as claimed in the previous meeting was seen at the site. No device was seen installed in the leach ate pit for measuring the leach ate produced at the yard. Therefore, no reliable data was available. Given the quantity of waste received (approximately 100 tonnes per day), and the lack of frequent turning, the quantity of leach ate produced may be expected to be 50 m^3 per day as per expert opinion.

A leach ate treatment plant has been erected at the site. It was not functioning. The design is non-standard, and it is unlikely to be effective. Therefore, the environmental Engineer of Kochi Corporation who was there at the site was advised that the best option is to collect the leach ate and deliver the same by tanker to nearby Septage Treatment Plant at Brahmapuram or at Wellington Island.

In the next meeting of the SLMC held on 14.6.2019, the following observations were made.

"It was noticed with distress by the SLMC that a good number of directions issued to the Corporation in the matter are yet to be complied with and therefore expressed displeasure over the same.

The Chairman, SLMC as well as the Additional Chief Secretary, Local Self Government opined that significant progress in waste management has to be made by the Kochi Corporation."

The following resolutions were taken in the meeting:

1. *The proposal for bio-mining is to be vetted by PCB.*
2. *Suchitwa Mission shall prepare proposal for bio-mining at Kozhikode, Njaliyan Parambu also.*

3. *The list of bulk generators has to be submitted by Kochi Corporation within 15 days.*
4. *Directions shall be issued by the Corporation to the bulk generators to take steps to channelize their own wastes. As the same is homogenous and clean, channelization can easily be done.*
5. *The details of wards, in which segregation is complete are to be submitted.*
6. *Segregated plastic waste for shredding has to be stored in areas attached to the zonal offices of the Corporation.*
7. *Training for commercial establishments, hotel and restaurant associations and residents associations be given by Suchitwa Mission. (Action: Suchitwa Mission)*
8. *The Corporations shall submit action plan containing the following details;*
    a. *Action taken by Kochi Corporation in each ward for waste management as per SWM Rules, 2016.*
    b. *Details regarding Projects which will be implemented urgently.*
    c. *Details for improving the existing waste management facility.*
    d. *Details of existing material collection facilities (MCFs)*
    e. *Details of wards in which MCFs have to be established.*
    f. *Details of places were Resource Recovery Facilities (RRFs) are functioning.*
    g. *Details of the locations in which RRFs has to be newly established.*
9. *The Corporation shall publish the following pieces of information in the website for the public.*
    a. *Details of locations at which bio-degradable waste treatment bins are functioning.*
    b. *Details regarding when and where the non bio-degradable wastes will be collected.*
    c. *Details regarding locations where bio bins for bio-degradable wastes collection have been established.*
    d. *Locations where MCFs are functioning.*
    e. *Locations where RRFs are functioning.*
    f. *Details regarding agencies entrusted for waste collection on ward basis.*
    g. *Details regarding where the waste collected by the above agencies are treated.*
    h. *Details regarding collection of non biodegradable waste.*
    i. *Details regarding the treatment of how and where non biodegradable wastes are treated.*
    j. *Source collection shall be extended in all wards as per NULM project.*
10. *The Corporation should examine how the service of Clean Kerala Company be made use of for treatment of no- biodegradable waste & e-waste.*
11. *Kochi Corporation should take legal action against open burning non- biodegradable waste including plastic and dumping of waste in water bodies.*

12. *Corporation shall take steps to establish MCFs in all wards and RRF at least in six wards.*
13. *Corporation shall prepare an action plan for developing a business model for effective treatment of waste.*
14. *Identity card should be issued to all workers engaged in waste collection. Necessary training should be imparted to workers.*
15. *If possible, non degradable waste other than plastics should be collected one or two days during every month.*

The aforesaid directions as well as the previous directions which were not hither to complied with shall be implemented in letter and spirit within 30 days from today. The failure will be taken note of seriously."

The progress in waste management in Kochi Corporation with special reference in Brahmapuram plant was again considered by the SLMC in its meeting held on 3.8.2019 as Agenda No.2. The true extract of the minutes on the agenda No.2 of the meeting dated 03.08.2019 is given below.

"The Action Plan as well as the action taken report submitted by the Secretary, Municipal Corporation, Kochi which are appended are Annexures-A and B to these minutes were considered by the Committee.

The Chairman, SLMC observed that if the proposed action plan is adhered to, the Corporation would not become fully compliant regarding the implementation of the Environmental Laws within the time (one year) specified by the Hon'ble National Green Tribunal. The progress of bi-mining proposed by the Corporation was also enquired into by the Chairman.

The Environmental Engineer, Kochi Corporation replied that a proposal was submitted to the Kerala State Pollution Control Board for vetting. A presentation was also done by him on the action taken so far as per the previous directions issued by the SLMC.

The Chairman, Kerala State Pollution Control Board clarified that the proposal had been vetted and returned to the Corporation. It was also asserted by him that the contractor who is engaged for bio-mining should enter into agreements with cement industries as well as thermal power plants for off take of the combustible fraction of waste.

The Additional Chief Secretary, Local Self Government Department instructed that, the Environmental Engineer of the Corporation should visit the office of the Kerala State Pollution Control Board and finalize the proposal expeditiously in a joint sitting. The Corporation was directed to ensure that un-segregated waste do not reach Brahmapuram Plant.

The Member Secretary, Kerala State Pollution Control Board cautioned that the Board would be constrained to levy Environmental Compensation for violation of Municipal Solid Waste Management Rules.

The Environmental Engineer, Kerala State Pollution Control Board informed that the Board had directed the Corporation to monitor the quality of treated leach ate.

Executive Director, Suchitwa Mission suggested that in addition to door to door collection, there should be manned common collection points where people can drop off wastes, as the same would be helpful for the people who are unable to adjust with collection time table of the Corporation."

The following resolutions were taken in the meeting:

1. *Corporation should finalize the tender specification within five days.*
2. *Contractor appointed for the bio-mining should enter into agreement with Cement Industries/Thermal Power Plants for off take of the combustible fraction of wastes.*
3. *Pipe line for conveying the leach ate should be laid from the uncovered leach ate collecting pit at Brahmapuram to the Septage Treatment Plant for treatment.*
4. *The Health Supervisor of Cochin Corporation Sri. Thomas Joshy should ensure that, 100% door to door collection from all households in all the seventy four wards of the Corporation as well as commercial institutions is implemented by 31st of August. The Secretary should monitor the progress on weekly basis.*
5. *The report regarding door to door collection should include details such as frequency of collection of biodegradable and non bio degradable wastes, number of workers engaged and number of vehicles utilized for this purpose.*
6. *The proposal for bio-mining got vetted by the KSPCB shall be implemented within three weeks."*

Meanwhile, the Chairman, KSPCB issued a notice on 12.10.2019 to the Corporation of Kochi under Section 5 of the Environmental Protection Act, 1986 for non compliance of Solid Waste Management Rules, 2016 with a direction to take steps to provide biomethanation plant for the food waste generated within the Corporation and to report compliance of all the directions referred to in the notice within 15 days for avoiding further action including recovery of environmental compensation for noncompliance.

The Secretary, Kochi Corporation gave a detailed reply dated 28.10.2019 (wrongly typed as 25.07.2019 on the facing sheet) along with a report regarding the actions said to have taken after the meeting of the SLMC on 03.08.2019.

For examining the genuineness of the averments in Annexure-X6, the Chairman, SLMC conducted a local inspection of the Brahmapuram site along with Chief Environmental Engineer, Regional Office, KSPCB, Ernakulam on 16.10.2019. The inspection revealed the following:

The site was in a state of disrepair. The onset of monsoon during the previous months had worsened the situation. Various short comings on the part

of the Corporation in maintaining the facilities in accordance with the Solid Wastes Management Rules and the directions of the SLMC were noticed.

No records were provided for assessing the quantity of manure production. Previously, the manure called 'city compost' generated in the yard, had been subjected to chemical analysis. It was found that the manure did not meet the standard stipulated.

The Corporation had failed to set up anaerobic digesters proposed by the KSPCB in reducing the quantity of solid waste.

No action had been taken to install proper effluent treatment facilities. All most all windrow sheds were in a dilapidated state.

The drain provided for leach ate was found blocked with hard slurry flowing from the compost yards and the primary biodegradable dumping area. Though it was reported by the Corporation that works on the drain had almost been completed, a major portion of it was found open, giving chance of oozing slurry from open dump sites and storm water entering it. There was no regular removal of leach ate from the collecting pits.

Water storage facility to prevent fire hazards was not seen provided in the site, in spite of specific repeated directions in the matter.

Though, directions were issued to install sufficient surveillance cameras inside the plant, (this was on account of a suspicion raised by the Corporation that the first fire incident might be on account of sabotage) only nine cameras were seen installed which are insufficient to cover all the strategic points.

Again, the SLMC in its meeting held on 8.11.2019, reviewed the issue as Agenda No.2.

The true extract of the minutes on said agenda is given below.

> "*The Chairman, SLMC informed the meeting that he along with the Chief Environmental Engineer, Kerala State Pollution Control Board, Regional Office, Ernakulam conducted an inspection of the Brahmapuram Dumping Yard on 16.10.2019 to verify whether the directions issued by the SLMC to the Municipal Corporation, Kochi regarding the activities to be done to mitigate the existing hazards. The Chairman informed that the experience of quite distressing.*
>
> *It was pointed out that the specific directions issued by the SLMC regarding the installation of cameras, installation of water tank, providing drains for conveying leach ate, etc., were not complied with. It was also pointed out by the Chairman that there are various shortcomings on the part of the Corporation in maintaining the facility in accordance with the Solid Waste Management Rules and as directed by the SLMC.*
>
> *The following are the shortcomings pointed out by the Chairman.*

a. *The quantity of city compost produced out of the bio-degradable waste dumped at the site is marginal compared to the daily waste collected by the Corporation.*
b. *No records were provided for assessing the quantity of the production of the city compost.*
c. *The Corporation has failed to set-up anaerobic digesters proposed by the KSPCB which could have reduced the quantity of solid wastes collected and dumped at the yard.*
d. *No action has been taken to install proper effluent facilities as agreed to by the Corporation in the previous meetings.*
e. *All the windrow sheds are in a dilapidated state.*
f. *The construction of the drain around the dumping site is not completed so far.*
g. *The portion of the drain already constructed is not properly covered by concrete slabs. Old slabs discarded elsewhere are seen placed over the drain at few places for name sake. As the drains are partly open there is every chance of oozed slurry from the open dump site and storm water entering the drain.*
h. *The existing drain provided is blocked with hard slurry flowing from windrow compost yards and the primary bio-degradable dumping area.*
i. *The leach ate collected in the existing leach ate collecting pit which is only few meters away from Kadamprayar is not being removed regularly, resulting in overflow of the leach ate to the nearby vicinities including the Kadamprayar, especially during rainy season.*

The representatives of the Kochi Municipal Corporation were directed to furnish their explanation for the aforesaid non-compliances.

The Assistant Secretary, Kochi Corporation reported the following:

- *Security has been provided.*
- *Cameras have been installed.*
- *Tender was called and agreement signed for road construction.*
- *Administrative and technical sanction has been obtained for water tank.*
- *Retender was called for legacy waste management but nobody has responded.*

The Executive Engineer, Kochi Corporation submitted the following:

- *The area is flooded and works can be done only after the water recedes.*
- *Drain has been completed.*
- *For covering the drainage with slabs, decision of the council has to be obtained.*
- *New trommel will be installed*
- *All quotations are submitted at rate above the Public Work Department rate.*

The Additional Chief Secretary, Local Self Government Department observed that the minutes of the SLMC meetings ought to have been

included in the agenda of the Council meetings. He observed that this has not been done.

The Chairman, SLMC expressed displeasure over the inaction on the part of the Corporation in complying with the directions of the SLMC in letter and spirit. He also warned that if the Pollution Control Board does not take action against the Corporation, the matter will have to be reported to the Hon'ble NGT for appropriate action.

It was resolved that a report regarding the events hitherto taken place and the present situation be presented by the Chairman, SLMC before the Hon'ble NGT.

On 10.12.2019, the Kochi Corporation submitted another report regarding the action taken after the SLMC meeting held on 8.11.2019.

On 11.12.2019, the Chairman, KSPCB issued a notice to the Kochi Corporation to show cause why the Board shall not recover Environmental Compensation of Rs.1,12,20,000 (Rupees One Crore Twelve Lakh Twenty Thousand) from 22.11.2018 to 30.11.2019 from the Corporation for not taking steps to provide leach ate treatment plant and biomethanation plant and the non-compliance of Rule 22 of the SWM Rules.

It was replied against by the Corporation on 1.1.2020.

The aforesaid notice issued by the Kerala State Pollution Control Board was considered inter alia by this Tribunal on 31.02.2020 in Original Application Nos.442/2013(SZ), 20/2017(SZ) and 276/2017(SZ). In para 7 of the order dated 31.02.2020 the Chennai Bench observed as under;

"7. ***On going through the report submitted by the Kochi Corporation, we are not satisfied with the progress expected from them for implementation of the directions given by this Tribunal in O.A.No.606 of 2018. Even on the last hearing date in O.A.606 of 2018, the Principal Bench of National Green Tribunal at New Delhi had expressed its displeasure in the manner in which the implementation of Solid Waste Management Rules, 2016 are being carried out in the State of Kerala. It is not known as to what happened after the show cause notice issued by the Pollution Control Board. On receipt of the explanation from the Corporation, the Pollution Control Board is directed to pass appropriate orders and complete the proceedings initiated on the basis of their inspection and dispose of the same in accordance with law and come with compliance report before this Tribunal.***"

In the meantime, O.A.No.514/2019 came up for consideration of this Tribunal on 24.1.2020. On that day this Tribunal has ordered as follows:

"In view of unsatisfactory state of affairs noticed above, let the Secretary, Urban Development, Kerala remain present in person on the next date with tangible progress failing which this Tribunal may be left with no other option except to take stringent measures for enforcement of law as per the provisions of the NGT Act, 2010.

List again on 28.02.2020.

A copy of this order be sent to the Secretary, Urban Development, Kerala by e-mail."

In order to place a a comprehensive factual report before this Tribunal, the Chairman, SLMC along with the Chief Environmental Engineer, Regional Office, Ernakulam again conducted an inspection of Brahmapuram yard on 18.2.2020 at 11 a.m. Mr.Raphimon T.M., Health Inspector and Mr.Binoy, Overseer were there at the site. Mr.Kiran Surya K.T., Environmental Engineer of the Corporation joined later.

The windrow composting yard, the garland drains around the yards, the leach ate collection pit, plastic shredding unit, septage treatment plant, area earmarked legacy waste, etc were inspected.

The following short comings were noticed during the inspection.

a. *The condition of windrow composting shed was seen deteriorated. It is preferable to remove those structures as they are incapable of being repaired. (Kindly see Figures 1 and 2 of Annexure-X11)*
b. *The production of compost is minimal on account of the sluggish nature of the bio-mining activity going on. Only three trammel machines were seen used which are insufficient to wipe out the quantity of bio-waste dumped at the site. Resultantly, the waste masses stocked are piling up. Thus legacy wastes get accumulated.*
c. *In spite of the specific direction issued to cover the garland drains, several portion of the drain were left uncovered. At certain portions, the drain was covered with slabs of decrepit nature (Kindly see Figure 3 in Annexure-X11). As the drains are not constructed scientifically there are chances of percolation of leach ate to the surrounding area.*
d. *Leach ate was seen flowing in huge quantity through a small canal which in turn percolate down. This can be seen in Figure 2 of Annexure-X11.*
e. *Though, there were repeated directions to provide scientific leach ate collection pit of impervious nature, it was not done. (Figure 5 in Annexure-X11 is the present leach ate collection pit). The ongoing construction of a new collection pit was noticed near the side of the existing leach ate*

collection pit. (Kindly see Figure 6 in Annexure-X11) The construction of the same also is in an unscientific manner and without intimating the KSPCB. The officials presented at the site claimed that a new pit would be a concrete pit having a capacity of 75,000 Litres. As pointed out at the outset, the site is wet land near the river Kadambrayar. Unless proper construction of the pit as well as constant removal of leach ate from the pit are ensured, there would be chances of percolation and overflow, permitting the present affairs to continue.

f. Though there is a leach ate treatment plant in the yard it is not operational (Kindly see Figure 8 in Annexure-X11). The officials present at the site stated that there is plan to introduce another one. However, there is no specific proposal for the same.

g. Though there is a plastic shredding unit in the yard it is remaining idle. There were no signs of functioning in the near past. The officials could not give a cogent reply regarding the date on which the unit was closed.

h. The quantum of legacy waste could not be assessed till date. The corporation does not have any proposal to conduct survey for the assessment of the legacy waste (Figure 11 in Annexure-X11is the dump site of the legacy waste).

i. The claim of the officials of the Corporation was that leach ate from the present collecting pit is being transferred daily in Tanker Lorries to the nearby septage treatment plant. At the time of inspection, a tanker lorry was seen at the site, loading the leach ate from the collection pit. This was seen taken to the septage treatment plant. However, it could be noted that on account of the construction of the new pit near the old pit, leach ate from the old pit has percolated to the new pit which was being siphoned out to the nearby land using suction pumps. A long hose was seen spread over the area to facilitate the siphoning process (Kindly see Figure 7 in Annexure-X11). Presumably, a major portion of the leach ate collected at the old pit and percolated to the new pit was being pumped out as above. The transportation of the leach ate to the septage treatment plant using tankers was for name sake only.

j. The officials, on the strength of a log book maintained in the septage treatment plant, claimed that approximately 5 loads of leach ate are transported daily from the pit to the treatment plant. However, the veracity of the same can be ascertained only if there are proper flow meters. The flow meter in situ was not functioning. The claim of the officials could not be verified from the recordings of the one and only camera installed on the

front gate of the plant. The footage showed 12 vehicles have entered the premises on 16.2.2020. However, this include the vehicles carrying septage from other parts of the district also.

k. *The outlet portion of the septage treatment facility was seen dirt as black coloured effluent was seen spread over there. The treatment effluent was seen discharged to the land on the western side of the treatment plant. On request, the officials submitted the analysis report of the effluent, dated 30.11.2019 issued by the District Office of the KSPCB, Perumbavoor. As the said test report did not inspire confidence on account of the blackish nature of the effluent, the Regional Office of the KSPCB was directed to take samples of the effluent again and subject the same to further analysis.*

l. *It was distressing to note that in spite of the repeated directions to provide an overhead tank of sufficient capacity with heavy duty pump-sets to prevent fire hazards, the same has not been provided till date. Every time the authorities of the Corporation gave readymade answers viz., that the work has been tendered, clearance is awaited from other authorities etc. As auto ignition in waste dumping yards is a common phenomenon, especially during summer season, it is inevitable to have a fire fighting devise at the yard for immediate prevention of fire breaks.*

The only direction seen implemented by the Corporation is the construction of roads through the different parts of the dumping yard which makes interior portions accessible to vehicles.

No sooner did the team reach the office after inspection, information was received that another fire broke out at Brahmapuram Yard at about 2.30 p.m. on the same day, ie., 18.02.2020.

The surveillance team of KSPCB who reached the yard without delay, analysed the atmospheric condition using toxic gas analysers. On analysis, it was observed that the ozone concentration was beyond the tolerance level. It was 0.52 ppm where as the permissible limit is 0.1 ppm. However, by about 8 p.m., the concentration was seen reduced to 0.18 ppm.

The fire could be contained by the fire department by the evening of 19.2.2020. This time it was easy for the fire force to reach the interior points of the yard as roads have been constructed inside the yard as directed by the SLMC.

After the fire incident during last year, the dioxin level at the area was got assessed by the CSIR-NIIST, Thiruvananthapuram. Therefore, the Member Secretary, KSPCB was addressed on 19.2.2020 to request the same authority to

assess the present dioxin level at the site as well as the long term effect of such fire break out using the previous report for comparative valuation.

Accordingly they have submitted a report which is appended as **Annexure-1** to this report. Their findings are given at pages 33 to 36 of Annexure-1.

The Chief Environmental Engineer of KSPCB, Regional Office, Ernakulam on 26.02.2021 has reported that his team along with an official from the environmental monitoring cell, Government Secretariat, Thiruvananthapuram had visited Brahmapuram yard on 09.02.2021 as a follow up on the action already initiated to verify whether there was any progress regarding the effective implementation of Solid Waste Management Rules in the yard. He has pointed the following short comings noted during the joint inspection.

1. *Fresh bio-degradable and non-biodegradable wastes are not segregated at source before transferred to the yard though separate log books were kept for non-degradable and bio-degradable waste.*
2. *Waste was being dumped in the open yard also.*
3. *The CCTV Cameras installed at the site were not connected to the surveillance wing of KSPCB thereby making the surveillance of the day-to-day operations impossible.*
4. *There is failure to install proper effluent treatment facilities at the site. The leach ate collected in a pit at the site was seen transported to a nearby common septage treatment plant.*
5. *The construction of the drains were not completed. The existing drains are in dilapidated condition with settled slurry from different yards.*
6. *The existing septage plant in the locality was not properly functioning.*
7. *Quantity wise details of waste transported to the yard from different local bodies were not provided to KSPCB in spite of repeated request from them.*
8. *Bio-mining of the legacy waste was going at a low phase*
9. *The manure received out of bio-mining is sold in the open market as 'city compost' which when analysed for its fertilizer value was not meeting the standard stipulated as per Solid Waste Management Rules, 2016. Presence of heavy metals was detected in the manure.*
10. *There is failure in processing non –biodegradable waste especially plastic kept in huge heaps at the site. The shredder installed at the site was seen idle.*
11. *Sufficient windrows are not provided.*

12. *Fresh bio-degradable waste was being dumped above the legacy waste heaps.*

13. *The temporary leach ate plant at the site was not working.*

14. *There was inadequacy of leach ate drains.*

15. *Existing drains were kept open leaving room for overflow during rainy season.*

The Chief Environmental Engineer further reported that certain follow up action were initiated by the government as well as Corporation as detailed below:

a. Management of Legacy Waste

Though the Corporation failed to do biomining as per the commitment, the Government had made certain interventions for the scientific disposal of legacy waste at Brahmapuram. As per G.O(Ms)No.08/2020/DMD dated 06/03/2020 Government have entrusted Kerala State Industrial Development Corporation (KSIDC) to initiate tender procedure for identifying a suitable agency for carrying out the rehabilitation of Municipal Solid Waste (MSW) dumpsite at Brahmapuram in Ernakulam district after cancelling the tender floated by Kochi Municipal Corporation. Accordingly KSIDC had floated e-tender on 20th March 2020 for identifying a suitable agency for the rehabilitation of MSW dumpsite at Brahmapuram in Ernakulam District. As per G.O(Rt)No.985/2020/LSGD dated 26/05/2020 Government have constituted a Technical Evaluation Committee chaired by Principal Secretary LSG (Urban) Department to evaluate the technical bids received for the project. After completing the tender process, KSIDC has submitted the report to Government for taking further steps through Kochi Municipal Corporation.

b. Management of solid waste.

It is noticed that the concessionaire M/s. G.J. Eco Power Pvt. Ltd miserably failed to implement the waste to energy project and the Government as per G.O.(Rt.)No.805/2020/LSGD Dated 30.04.2020 had cancelled the approval granted to the project and the Secretary, Kochi Municipal Corporation has been directed to take immediate steps to terminate the Concession Agreement executed with M/s. G.J. Eco Power Pvt. Ltd for the implementation of the project. However, from the reports submitted before this Tribunal following observations were made.

a. Government has entrusted the works to KSIDC and they floated e-tender for the project on 24th June 2020.
b. The technical bids received in e-tender portal opened on 16th September 2020 and the two agencies submitted bids for the project were Consortium

led by M/s. Tholani Clean Energy Pvt. Ltd., Kochi and Consortium led by M/s. Zonta Infratech Pvt. Ltd., Bangalore.

c. The technical bids submitted by the two agencies were evaluated by the Bid Evaluation Committee on 07.01.2021.

d. It was found that only one bidder was qualified. The Committee recommended for retendering the work in accordance with Government orders. In case of single bid found qualified for a work, a mandatory second bidding is to be done.

e. Accordingly, the bids have been invited again, however, keeping the least 15 working days as the time framework.

Though they had submitted that the work for WtoE plant would be awarded in February 2021, no further progress is reported till date.

To examine the quantity of legacy waste, survey of the area to be biomined is to be conducted and for that Kochi Corporation had requested to NIT Calicut to submit their terms and conditions to conduct the said survey. It is understood that such surveys were conducted during second week of February 2021.

On 3.3.2021, I along with the Chief Environmental Engineer, KSPCB, Regional Office, Ernakulam conducted a joint inspection of the Brahmapuram Yard. The following short comings were noted during the inspection.

1. *In spite of the repeated directions from the State Level Monitoring Committee as well as from the KSPCB, segregation of wastes at source is not practiced.*
2. *The waste materials received at the yard is not in the segregated form. Fresh waste materials brought from the limits of different local bodies were being dumped over the existing legacy waste. At the time of my visit, a heavy vehicle carrying waste from Aluva Municipality was seen unloading fresh waste over the legacy waste.*
3. *A major portion of the windrow composing shed was in a dilapidated condition. The damaged condition of the shed is one of the causes for the malfunctioning of solid management facility as the rain water during the monsoon is allowed to fall over the legacy waste deposited there, leading the flow of leach ate to river Kadamprayar in the vicinity.*
4. *Tons of legacy waste were seen accumulated inside and outside the windrow composting sheds.*
5. *Leach ate was seen flowing from windrow composting sheds.*
6. *Major portion of the drains intended to carry leach ate were uncovered.*

7. Uncovered drains were seen blocked by legacy waste preventing the leachate flow. The uncovered legacy waste and the adjacent open drains make the leach ate treatment unviable.
8. There were visible discharge routs which appear to be intentionally created for the discharge of untreated waste which would find its way to the adjacent marshy area and ultimately to river Kadamprayar as well as a branch of Chithrapuzha which are identified as polluted stretches of rivers by the Central Pollution Control Board.
9. The bio-mining process was only name sake and was going at a low pace using two machines only. This will be an unending process so long as no effective bio-mining is carried out.
10. No action has been taken so far to install an effluent treatment plant facility at the dumping site. At present, the leach ate from the yard reaches a nearby collecting pit through different drains from where it is collected in Tanker Lorries. It is claimed that the same is treated as the common septage treatment facility in the same locality.
11. The visit to the common septage treatment plant on the same day revealed that the plant was not functioning. The filter feed tank of the septage treatment plant was non-functional. The sludge drying bed of the septage treatment plant was filled with weeds which would indicate that the plant was lying idle for so many months. The flow meter installed at the plant was found faulty. At the time of my visit, a tanker lorry filled with leach ate came to the plant and the content was released into the collecting tank of the treatment plant. It is relevant to note that there were no signs of such activity before, at that particular point. However, leach ate was seen released to a small drainage by the side of the plant using a huge flexible hoes. Tire marks of the heavy vehicle were seen at that spot. Spilled over leach ate was also found at that area. This gave a clear indication that untreated leach ate brought to the plant in tanker lorries was being discharged in the same condition using the flexible hoes directly into the drain which ultimately reaches a marshy area about fifty meters away from the plant. The aforesaid marshy area extends up to Chithrapuzha river named above. It is relevant to note that there was adverse remarks from the Principal Bench of NGT on the feasibility of transfer of leach ate to the septage plant for treatment.
12. Plastic waste materials were dumped openly along the south east portion of the yard. No facility was seen for processing the same. There is a shed incapable of accommodating the entire plastic wastes to the yard. The shredding unit was lying idle.

A fire accident occurred at the plastic dumping area of the yard again on 5.3.2021 ie., one day after my visit. Knowing the incident the surveillance team of the Board rushed to the spot.

However, the Fire and Rescue team was able to control the fire by night. After the said fire incident the Director (Technical), Fire and Rescue Services, Kerala forwarded a report on 27.3.2021 to the Chief Environmental Engineer, Regional Office, KSPCB, Ernakulam. Following were the difficulties faced by the team deployed to extinguish the fire.

a. *Absence of facilities for providing hydrants at the incident spot.*
b. *Non availability of vehicular tracks in yard for accessing in the areas under fire. Here it is relevant note in the first meeting itself the Corporation was directed to provide sufficient vehicular track for having access to all areas of the yard during emergency situations. Though initially few road were cut through the yard which was useful in putting out the fire during the 2nd incident that roads could not be used during that time as those areas were also dumped waste materials.*
c. *Uneven surface of the yard retarding the speed of fire engines.*
d. *Frequent change in the direction of the wind.*
e. *Breathing problems to the rescue personal due to the inhalation of toxic smoke which affected the speed of the operations and absence of facilities to provide first aid.*
f. *Absence of security guards in the yard.*
g. *Inadequacy of hydrant facilities and the lack of experience among the Corporation staff to make it functional.*
h. *Inadequacy of JCB and proclaimer during the operation.*

However, these inadequacies were not addressed by the Corporation as could be revealed from the recurrence of subsequent fire incidents.

The following remedial measures to be taken by the Corporation were also suggested by the Fire and Rescue Department in the aforesaid report.

1. *Machineries have to be set up for the treatment of degradable as well as non-degradable waste immediately.*
2. *The existing waste materials have to be clustered limiting the area of each cluster 750 Sq.Mtr.*
3. *Construction of a road having a width of 10 Mtrs.around the yard as well as roads having a width of 7 Mtrs. around each cluster for having excess to all areas of the yard during emergency situations.*

4. *Deployment of at least eight security staff during day time and five security staff during night time for surveillance in the yard.*
5. *Installation of CCTV Cameras at different parts of the yard.*
6. *Providing a permanent fire fighting mechanism in the yard and giving adequate training to operate the same, to the staff on duty.*
7. *Arrangement of training courses to the staff on duty with the assistance of the Fire and Rescue Department.*
8. *Installation of the following machineries in the yard.*
    a. *Twin hydrant outlet (rotatable at 360 Degree) with fixed monitor, on either side (in the opposite direction). The hydrant line should have a diameter of 150 mm.*
    b. *Ring main distribution system around the yard (ring distribution systems are designed so that every distribution transformer connects with two feeders using different pathis).*
    c. *Platforms in river Kadamprayar with intermittent gap of 30 Mtrs.*
    d. *Fire Pump Room with electric pump capacity of 2850 Lpm and stand by Diesel Pump with same capacity.*
    e. *An open water source reservoir a capacity of 5 Lakhs Ltrs. and a pump set having a capacity of 800 Lpm to pump water from river Kadamprayar to the reservoir.*
    f. *Delivery hose 25 Nos.*
    g. *Suction hose 10 Nos.*
    h. *Ordinary branches 5 Nos.*
    i. *Metal Steiner 5 Nos.*
    j. *Basket Steiner 5 Nos.*
    k. *Fire pump having a minimum capacity of 5 lack Ltrs.*

All these suggestions went into deaf ears as evident from the subsequent repetition of fire incidents in the yard.

Again at about 5 p.m on 18.1.2022 I received a message from the Chief Environmental Engineer, Kerala State Pollution Control Board, Regional Office, Ernakulam informing that there was a fire outbreak in the Solid Waste Dumping Yard at Brahmapuram during the course of the day. (It was on the same day that there was an outbreak of fire at the plastic waste storage yard at Kalamassery, regarding which I have forwarded a report on 23.01.2022).

I along with the Chief Environmental Engineer, KSPCB, Regional Office, Ernakulam inspected the site at about 12.30 p.m. on 20.01.2022 and a report was forwarded to this Tribunal on 24.1.2022.

The fire incident on 18.1.2022 was at the area where old plastic materials were heaped. This is at the southern boundary of the yard. This area is boarded on the south by a tributary of the river Chithrapuzha. The Fire and Secure team was able to control the fire during the same night itself. However, it is learnt that there was emission of heavy smoke due to the burning of plastic. During my inspection on 20.1.2022, water hydrants were seen operational and no fire or smoke was observed at that time. It is crucial to note that there was no improvement in the general condition of the entire dumping yard described in my previous report dated 28.07.2021.

The latest among the series occurred on 2nd March 2023.

As my health condition did not permit me to expose myself to the toxious fumes, I could inspect the yard only on 6th March 2023. The Chief Environmental Engineer, Regional Office, KSPCB, Ernakulam accompanied me.

Number of fire fighters with fire tenders from various parts of the State were seen deployed in the fire fighting operation. Two Helicopters from Indian Navy were seen deployed for areal operation.

The following details could be gathered from the Fire and Rescue personal at the yard.

Information regarding the fire incident was received at about 3 pm on 2.3.2023, at the Thrikkakkara Unit of Fire and Rescue Services. Fire tenders from Ernakulam, Kottayam and Palakkad Districts were pressed into service. The operation was not successful on the first day because of various reasons. Firstly, the fire tenders couldn't get access to the Kadamprayar river. The heaps of waste which caught fire were having height of 20 to 25 feet and the hydrants were easily evaporated by the emission of heat due to the burning of mixed waste significant portion of which is plastic.

On the 2nd day, the heaps were dislodged using earth removers. Simultaneously hydrants were showered. On that day the fire fighting personal could open a way across the yard reaching up to river Kadamprayar. This was helpful in pumping water from the river. Eight portable pump sets of 5000 Ltr. capacity were used in the operation. The operation was made easier by dividing the area in the clusters.

Initially, the areal operation caused some diffifulty to the ground operators as the smoke emanating from the yard again came to ground due to the forceful downward air current while the Helicopters were operational.

It is learnt that about 20 Fire and Rescue personal had some health problems, though temporarily, due to the inhalation of toxious smoke.

The shift in the direction of the wind current also slowed down the process as the location of the fire tenders had to be shifted periodically following the direction of the wind. However, due to the continues effort of the fire fighters, the blaze could be controlled by the evening of the 3rd day. However, bellowing of toxic smoke continued for many days.

Environmental impact of burning of plastic

When degradable and non-degradable waste materials are heaped for a long period of time, the degradable waste at the bottom will undergo an anaerobic decomposition in the absence of oxygen which may generate combustible gases like Methane, which if caught fire, has a devastating effect and it may not be possible to control the fire easily. When Methane is burnt multiple compounds which are very dangerous to living beings are generated. The impact of the same will continue even for generations.

When bio-degradable waste along with halogenated plastics (For Example: PVC) burn partially (thick fumes indicate such partial burning) very dangerous toxins like dioxins are generated. Dioxins are polychlorinated dibenzo-p-dioxin, shortened as dioxin. The dangerous nature of this compound was known to the world when USA made use of a defoliant by name TCDD commonly known as 'Agent Orange' in Vietnam War. It is a persistent organic pollutant.

It is curious to note that the dioxin level in the atmosphere in two previous fire incidents at Brahmapuram, which were subjected to a study by NIIST (the details are given in the earlier part of this report) were beyond the tolerance level.

This time also the NIIST was advised to conduct a study and to submit a report, the result is awaited.

The shortcomings noticed at the yard during the inspection on 02.03.2023.

1. *There was no considerable progress in the process of bio-mining said to have been under taken by an independent service provider. Two machines for bio-mining were lying idle in the yard. Presumably, this may be due the then fire incident. Two representatives of the service provider were present at the site.*

They claim that bio-mining process is being carried out by them sector by sector. Though they have pointed out at the area which according to them was cleared by bio-mining process, that area was negligible compared to the un cleared area. On a specific quarry as to whether they have deployed any fire fighting mechanism to prevent accidental fire they claimed that they had fire extinguishers. It is doubtful whether any adequate fire fighting mechanism was maintained by them in the yard.

2. *I have examined the log books seen in the Cabin at the entrance of the yard. Two separate log books were kept for biodegradable waste as well as plastic waste. However, the entries were made in a shabby and peremptory manner without full details.*
3. *No permanent fire fighting devices were found. The representatives of the Corporation stated that a pump set of 75 HP capacity was installed near the river with hydrant line having 6 valves and 11 outlets. However, it was admitted that it could not be made functional as the food valve of the pump immerced in the river was blocked by mud and plastic waste.*
4. *There was no open reservoir to store hydrant for use in the case of emergency. Installation of a pump set without any storing facility will be no use during emergency. All the fire incidents hither to had occured during summer season. It is common knowledge that the rivers in Kerala are likely to be dried up during summer. Installation of the pump set with foot valve immersed in river is bound to fail during summer season as the water level would be far below the foot valve.*
5. *A portion of RDF collected from bio-mining was seen baled and stacked in the land proposed for waste to energy plant and another portion was seen stored near the windrow composting plant area.*
6. *The leach ate waste leading to the leach ate collection plant was found to be blocked. The leachate drains still remain uncovered with slabs. During rainy season the overflow from these drainages shall ultimately reach the river Kadamprayar.*
7. *There is no significant change in the general condition of the yard. If the bio-mining process is going at this pace, it is not likely to be completed in the near future and it will invite dangers like the fire incidents occurred hitherto.*

The screen shots showing the condition of the yard from 2.3.2023 to 6.3.2023 (including the photographs taken at the time of my inspection) are appended as **Annexure-2 series**.

Punitive actions taken against the Kochi Municipal Corporation relating to the issues at Brahmapuram and their present status.

1. This Tribunal as per Order dated 31.5.2016 directed the Kerala State Pollution Control Board to prosecute the Officers who are responsible for consistent violation of Solid Waste Management Rules, 2016 regarding the Brahmapuram Yard.

   The said Order was stayed by the Hon'ble High Court as per Order dated 12.8.2016 in WP© No.24360/2016(V).

2. In OA Nos.533-535/2018 this Tribunal ordered time bound directions to the Corporation in the following matters.

   a) Establishment of the new integrated solid waste treatment processing plant to be completed within a period of six months.

   b) Treatment of the legacy waste at the present site to be commenced forthwith and to be carried out in accordance with the procedure laid down under the Solid Waste Management Rules, 2016.

      For the inordinate delay caused in taking up the work, a penalty of Rs.1 Crore was imposed upon the Kochi Municipal Corporation, 50% of which to be deposited with the Central Pollution Control Board and 50% with the Kerala State Pollution Control Board.

      There was further direction to furnish a Performance Guarantee of Rs.3 Crores with the SPCB within a period of 15 days from the date of the order to ensure completion within a time limit prescribed. It was also observed that failure to maintain the time line prescribed shall entail forfeiture of Performance Guarantee and imposition of additional penalty of Rs.2 lakhs per4 day till completion of the project.

      The aforesaid Order was challenged by the Kochi Municipal Corporation before the Hon'ble High Court in WP© No.36204/2018(A). The High Court as per Order dated 9.11.2018 allowed two months time on condition that the Corporation shall make Bank Guarantee for Rs.50 Lakhs each to CPCB and KSPCB. The Corporation was exempted from depositing performance guarantee for Rs.3 Crores. Thereafter, the aforesaid time was extended until further orders.

3. The KSPCB had issued a direction to the Corporation on 13.1.2021 imposing a Compensation of Rs.14.92 Crores for non-compliance of Solid Waste Management Rules, 2016 after assessing the environmental impact.

The said order was challenged by the Kochi Municipal Corporation before the High Court in WP©No.3478/2021 and had obtained a stay against the order on 9.3.2021.

4. The KSPCB issued on 4.3.2023 to the Kochi Municipal Corporation to show cause for not imposing an Environmenral Compensation of Rs.180 Lakh for the non compliance of Solid Waste Management Rules, 2016. Further action in the matter is awaited.

SUGGESTIONS AND CONCLUSION

All the fire incidents in Brahmapuram Yard were due to the failure of the Kochi Municipal Corporation in following the Environmental Laws, the Orders of this Tribunal as well as the directions of the State Level Monitoring Committee. After every incident there is much hue and cry from various corners which will gradually subside within a week. It appears that the Kochi Municipal Corporation is confident that nothing will happen thereafter. Fire incidents are likely to occur again unless the existing legacy wastes in the yard are cleared on war footing and proper scientific methods are adopted for future.

Here it is relevant to note that the waste materials collected from the local limits of Kochi Municipal Corporation and five other urban local bodies namely, Angamaly, Thrikkakkara, Kalamassery, Aluva and Thrippunithura as well as two Panchayath areas (Vadavucode – Puthencruz Panchayath and Cheranallur) are brought to the yard at Brahmapuram. As the other five urban local bodies as well as two panchaytas are the beneficiaries of the yard, the total expenses for establishing and running the waste treatment plant can be shared by the Kochi Municipal Corporation and the aforesaid local bodies. If there is any deficit it can be supplemented by the State Government as the project is for public benefit.

For preventing the fire incidents, it is necessary to set up permanent fire fighting mechanism as advised by the Fire and Rescue Department (Kindly see the suggestions at previous page Nos.20 & 21 in this report).

The right to life is an inherent natural right of every living being on this planet. The right to life and personal liberty guaranteed by our Constitution is only a declaration of the said natural right which takes in the right to live in a trouble free environment.

If the illegalities, perpetuated by the authorities who are bound to uphold and follow the laws promulgated for the benefit of the entire society, are not attended to and corrected timely, it will be branded as a grave error by the generations to come.

Dated this the 13th day of March, 2023.

Justice A.V.Ramakrishna Pillai
(Former Judge, High Court of Kerala)
Chairman, SLMC, Kerala.

ANNEXURE - 1

STUDY REPORT ON THE EMISSION OF DIOXINS AND FURANS DURING THE FIRE BREAKOUT AT BRAHMAPURAM WASTE TREATMENT PLANT – FEBRUARY 2020

Environmental Technology Division
CSIR - National Institute for Interdisciplinary Science & Technology
Thiruvananthapuram, Kerala – 695 019

Final Report

December 2021

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Acknowledgements

The study was urgently taken up at the initiative of Honourable Justice A.V. Ramakrishna Pillai, Chairman, State Level Monitoring Committee, an authority constituted by National Green Tribunal. Honourable Justice wrote to KSPCB to conduct a study on dioxin emission by NIIST as soon as the fire breakout incident at Brahmapuram waste dumpyard came to his notice on 19/02/2020. We express our sincere gratitude to Justice A. V. Ramakrishna Pillai for his keen interest and timely intervention to address such an important societal issue. We also thank Kerala State Pollution Control Board for quickly approaching us on the same day and providing the necessary support at the site. Open burning of municipal solid wastes is a major source of dioxin emission in developing countries and dumpyard fires are very common in the country. However, no studies on the dioxin emission during such firebreak out incident in India were reported until CSIR-NIIST has carried out the emission monitoring during the Brahmapuram - 2019 incident. The study report of 2019 incident was submitted to the stakeholders such as KSPCB, CPCB, MoEFCC and MoHUA.

We thank Dr. A.Ajayaghosh, Director, CSIR- NIIST for deputing us immediately to take up the study and facilitating the administrative and logistic support in executing the work at short notice. We gratefully acknowledge Dr. Ajit Haridas, former Chief Scientist, CSIR-NIIST & former Chairman, KSPCB for his significant contributions in establishing and upgrading the Dioxin Research Laboratory at CSIR-NIIST. We are extremely thankful to the significant contributions of Late Dr. Anbu Munusamy in establishing the unique national dioxin research facility at CSIR-NIIST way back in February 2005. Since June 2014, Dr. K. P. Prathish, Senior Scientist is leading the facility.

. India ratified Stockholm Convention on POPs in April 2006. NIIST is a participant institute in the National Implementation Plan (NIP) project on POPs coordinated by MoEFCC, which has conducted the accounting of POPs emission and envisaged a road map to reduce/eliminate POPs by BAT/BEP approaches during 2007-2011. Subsequently, NIIST upgraded the analytical facilities under the DSIR-NIIST- CRTDH project in 2016 to address some of the shortcomings

identified by the independent evaluators of NIP. We gratefully acknowledge the support of Department of Scientific & Industrial Research (DSIR) for funding the upgradation of the facility under CRTDH project.

We express our deep sense of gratitude to Kerala State Pollution Control Board (KSPCB) for funding the first study in India on the "Determination of emission factors of dioxins from open burning of municipal solid wastes in Kerala" using the upgraded facilities at NIIST. The study report was submitted to KSPCB and other stakeholders such as MoEFCC, MoHUA and CPCB in December 2018.

The present study during a second episode of fire breakout at Brahmapuram in February 2020 was carried out by the following team:

1. Dr. K. P. Prathish, Senior Scientist, CSIR- NIIST
2. Mr. Shaji Kumar. V.K, Senior Technical Officer, CSIR- NIIST
3. Mr. Ajay. S.V, Research Scholar, CSIR- NIIST
4. Mr. Rajendra Prasad & Mr. Ratheesh S, Casual Labourers

For further information, contact Dr. Prathish K P, 9447798707 prathishkp@niist.res.in.

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Executive Summary

Dioxins are a class of highly toxic persistent organic pollutants (POPs) unintentionally produced during various combustion processes such as waste incineration, open burning of MSW, chemical and metallurgical manufacturing processes etc. CSIR-NIIST established the first and unique dioxin research laboratory in India and is a participant institute in India's National Implementation Plan (NIP) submitted in April 2011. The lack of dioxin emission data from open burning of MSW was one of the major shortcomings identified by UNIDO's independent evaluators in India's NIP. Later on, a study funded by Kerala State Pollution Control Board (KSPCB) was carried out by NIIST during 2016-18 on the "Determination of emission factors of dioxins from open burning of municipal solid wastes in Kerala" and the report was submitted in December 2018.

Subsequently, CSIR- NIIST conducted a study on the emission of dioxins during massive fire breakout incident occurred at Brahmapuram municipal solid wastes dumpyard in Kochi during 22-25th February 2019. The study was taken up voluntarily by NIIST, as it was an actual massive scenario of the previously conducted laboratory scale studies and more evidence/information can be generated from the real time study. The total area of the site is approximately 110 acres and about 60 acres is covered with dumped MSW of more than 6 lakh tonnes. The study report was submitted to KSPCB, CPCB and MoEFCC in April 2019. Further, KSPCB submitted the report to Honourable Justice A.V. Ramakrishna Pillai, State Level Monitoring Committee, an authority constituted by National Green Tribunal.

Justice A. V. Ramakrishna Pillai came to know about a fresh case of similar fire breakout at Brahmapuram on 19th February 2020 and immediately wrote to KSPCB to approach CSIR-NIIST to carry out a study as in 2019.The fire was started on 18th February afternoon. KSPCB approached NIIST on 19th February evening, and immediately Dr. A. Ajayaghosh, Director, CSIR- NIIST approved to take up the work. The NIIST team led by Dr. K. P. Prathish, (Scientist in-charge, Dioxin Research Laboratory) made all necessary arrangements on war footing such as ambient air PUF samplers, generator, other accessories, pickup van and started on 20th February at around 11 am and reached the site in the late evening around 8.30 pm. It was informed by the workers that most of the fire is brought under control by the fire and rescue team by evening, and will continue the tilting and tumbling and watering of waste heaps on the next day as well to avoid any further escalation. The ambient air sampling was conducted during 21-22nd February 2020 and residual

ash samples were also collected from the site. It was then transported to Dioxin Research Laboratory on 23rd February 2020. The sample preparation, analysis and quantification of dioxins and furans were carried out at the NABL accredited (ISO/IEC 17025:2017) laboratory at CSIR-NIIST.

The following are the major findings of the present study.

1. Dioxins were detected and quantified in ambient air and residual ash samples collected from the premises of waste dumpyard during fire break out.

2. The average dioxin levels observed in **ambient air** was found to be **3.2 pg TEQ/m^3**. The observed levels are **16 and 2.5 times higher than reference and field blank data**.

3. The average dioxin concentration observed in **residual ash samples** collected from different locations in the fire covered area is **89.3 ng TEQ/kg of ash**.

4. The dioxin generated by the fire is given by Emission Factor x Activity Rate.

    1. The Activity Rate = total quantity of MSW burned = Area burned (from satellite image of 19/2/2020) x burn depth (20 cm), and bulk density (350 kg/m^3) = **1300 tonnes (appr.)**

    2. The **Emission Factor for dioxins** as determined in "Burn-hut" at CSIR-NIIST is **167 µg PCDD-F TEQWHO/ ton of waste burned**.

    3. Hence, estimated dioxin emitted = **221 milligram Toxicity equivalence (TEQ).**

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1.0 Introduction

Brahmapuram Municipal Solid Waste (MSW) treatment plant is the largest MSW disposal and management centre in the state. It is situated very near to the Cochin - smart city project and receives on an average of 350 metric tonnes of solid waste per day from 5 municipalities (Angamaly, Aluva, Kalamassery, Thrikakara, and Tripunithura) and 3 panchayaths (Cheranallur, Kumbalangi and Vadavucode-Puthercruz) in addition to Kochi corporation area [1]. The centre had facilities to process biodegradable wastes only, and are converted into manures. The source segregated plastics and other recyclables were stored separately at the centre and are sent off for recycling periodically. But the major fraction of wastes (70-80%) reaching the centre are in unsegregated, heterogenous nature and are literally dumped in the 110 acres of wetland in the catchment area of Kadambrayar. As per KSPCB, the windrow composting and MCF/MRF facilities are non-functional and wastes are mostly being dumped at the site. An approximate quantity of 6 lakh tons of solid wastes is dumped at the centre and concrete plans for site reclamation is still awaited [2]. There are no adequate leachate handling facilities and presently it is being transferred to septage treatment plant. A new waste to energy plant was proposed in 2017, but not yet implemented. In fact, it is extremely important to take steps to implement a scientific and effective waste treatment facility to manage the huge quantities of MSW generated in Kerala's industrial capital. The reclamation of the legacy waste dumpyard will be sustainable, only if a mechanism for scientifically treating the day to day generated wastes is established in tandem.

The open dumps of MSW have huge impact on the environmental and health status of the region. Open dumps are notorious for foul smelling gases, leachate issues and infectious vector breeding sites resulting in contaminated air, soil and water. In addition, the periodic incidents of massive fire breakouts in such dumpyards raise huge concerns to human health and environment. 7 major fire breakout incidents were reported at Brahmapuram during 2018-2020. The putrescible materials trapped under the dumps will get decomposed in the anoxic conditions underneath and can produce highly flammable methane gas in the pockets formed due to uneven dumping. These landfill gases can get triggered intentionally or unintentionally in the course of time and can lead to uncontrollable fire incidents in the waste heaps. As a result, huge quantity of hazardous emissions will occur in a very short period and also containment of the fires will be very challenging [3, 4].

Open burning of municipal solid wastes is considered to be the largest source of unintentionally produced persistent organic pollutant (U-POPs) emission in developing countries, although it is often ignored. U-POPs include polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxin-like Polychlorinated biphenyls (dl- PCBs) ("Dioxins" is the general term to represent these three groups) [5]. Dioxins are highly persistent, bio-accumulative and toxic organochlorine compounds which are classified as known carcinogens (Type A) by World Health Organization (WHO). These toxicants are reported to persist inside human body for about 7-12 years due to its lipophilicity and are known to cause mutagenic and teratogenic effects. The tolerable daily intake levels specified by WHO for dioxins is as low as 1-4 pgTEQ/kg of body weight, which underlines the extreme toxicity of these contaminants [6]. Phasing out/controlling emission of POPs from the earth surface is the long-term broad objective laid down by the Stockholm convention on POPs in 2001. India ratified the convention in 2006 and submitted its national implementation plan (NIP) on POPs management in 2011 [7]. CSIR-NIIST has been a participant institute in the NIP project along with CSIR-NEERI, CPCB, CPRI and HIL. NIIST continued its legacy in the area of dioxin research and monitoring (a unique national facility) and has recently conducted India's first experimental study on the emission factors of dioxins from open burning of MSW [8, 9]. NIIST has also conducted studies on the dioxin levels in sediments and fish samples collected from Eloor-Edayar industrial area, Ernakulam. Another important ongoing study is the estimation of dioxin & PCB emissions from small and medium scale waste incinerators.

Brahmapuram MSW treatment plant witness periodic fires during every summer season. CSIR-NIIST conducted an investigation on the emission of dioxins during the fire breakout incident in 22nd to 25th of February 2019. NIIST had submitted a detailed study report on the dioxin emission with recommendations to manage the legacy wastes in April 2019 to KSPCB, Kochi Corporation and Ernakulam district Collector [10]. Subsequently another similar fire breakout incident was reported on 18th February 2020. The fire started in the afternoon hours of 18/02/2020 and by evening the fire spread to a large area and thick smoke filled the atmosphere. The fire remained uncontrollable and in the next day the smoke escalated to the nearby places leading to smoke filled ambient air in the resident areas. CSIR-NIIST was informed by KSPCB about the incident on 19/02/2020 evening based on the suggestion given by Honourable Justice A. V. Ramakrishna Pillai, Chairman, State Level Monitoring Committee. NIIST took action on war footing to depute

the concerned scientist Dr. K. P. Prathish and team to the site. The team reached the site on 20/02/2020 late night and decided to start sampling on the next day morning, after assessing the site in day light. The workers and security officials informed that the active fire was brought under control by 20/02/2020 evening although smouldering is observed in certain heaps and water showering by tilting and tumbling of heaps will be continued next day as well to make sure that further escalation of fire is curtailed. The air sampling was completed on 22/02/2020 and 4 representative ash samples were also collected from site.

The ambient air, residual ash and sediment samples were transported to Dioxin Research Laboratory on 23rd February 2020. The sample preparation, analysis and quantification of dioxins and furans were carried out at the NABL accredited (ISO/IEC 17025:2005) laboratory at CSIR-NIIST. The present report reveals the major findings of the study and will augment our previous two study report on "Emission factors of dioxins from open burning of municipal solid wastes in Kerala" submitted to Kerala State Pollution Control Board in December 2018 and the study report on Brahmapuram dumpyard fire breakout incident in February 2019. We are hopeful that these studies will enable the regulatory agencies, health departments, and the government to take important policy decisions on scientific solid waste management. CSIR-NIIST is committed to provide any further information or services to the concerned stakeholders in this regard.

2.0 Materials and Methods

2.1 Equipment/apparatus

2.1.1 High-volume ambient air sampler

High-volume PUF samplers were used for sampling dioxins and furans from ambient air. A large volume of air (300-500 m^3) was passed through glass micro-fibre filter paper and Polyurethane foam plugs placed inside the high-volume sampler. The particulate bound dioxins were trapped in the filter paper while the volatile fraction get adsorbed onto the PUF plug placed beneath the filter paper in the sampling train.

APM 460 High volume PUF sampler (M/s. EnviroTech Instruments Pvt. Ltd, India; Fig - 1) was employed for the ambient air sampling from open burning sites in the study. The equipment has provisions for

1. Coarse particle collection cup with a settling cyclone – Air and dust entering the equipment passes through a settling cyclone apparatus where the coarse particles and particulates of larger size will get settled into a collection cup. The separate collection of these particles can reduce the clogging effect in the particulate filter. This can be retrieved on completion of sampling and can be used for the analysis.
2. Particulate matter filter paper (8" x 10") – Pre-weighed Whatman GD/A glass fiber filter paper was used for collecting particulate matter up to the size of 10 µm.
3. All glass PUF cartridges – Polyurethane foam media was used for adsorbing the vapour phase dioxins from the ambient air. To hold the PUF plug all glass made cartridge was used as metallic surfaces may react with dioxins.
4. Electromechanical time totalizer – the sampling duration was recorded in the instrument itself using automated timer which can be used to run the instrument for pre-set duration.

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Fig 1: Ambient air PUF sampler

2.1.2 Sample extraction apparatus

Classical Soxhlet extraction apparatus was used for the extraction of both air and ash samples (Fig 2). The Soxhlet apparatus consisted of

1. Solvent container – Extraction solvent can be taken in the solvent container and the soxhlet flask need to be connected to the ground joint solvent container.

2. Soxhlet flask – The sample is placed in the soxhlet flask and the hot solvent will extract the organics in the sample by the siphoning effect.

3. Condenser – Cold water will be circulated continuously in the condenser to cool and condense the hot solvent vapour generated during the extraction process.

Upon heating the solvent in the container get vaporised and move through the Soxhlet flask and reach the condenser on the top. The condensed hot solvent will drip back to the Soxhlet chamber where the sample is placed. The hot solvent will dissolve off the organic content in the sample matrix and on reaching the flask volume, it will flush out to the solvent container by siphoning action. The process is repeated for several cycles so as to ensure quantitative extraction of compounds of interest.

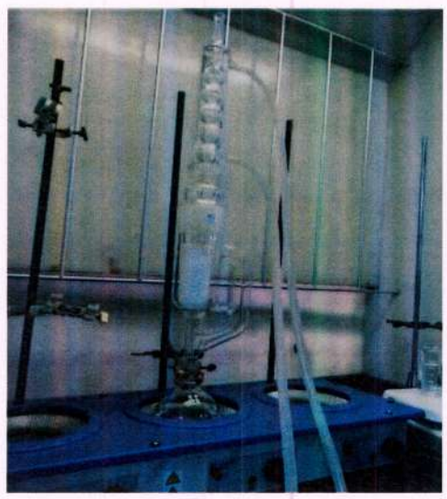

Fig 2: Soxhlet Extraction System

2.1.3 Automated and semi-automated sample cleanup system

The extracted sample obtained after Soxhlet process contain interfering compounds and co-extractants such as humic acids, polymeric ingredients, plasticizers, fatty materials and other organic impurities along with the compounds of interest. The removal and separation of these interfering matrices is essential for the quantification of dioxins. Sample cleanup is the rate determining step in the dioxin analysis as it involves multiple column cleanup procedures to remove the interfering matrices and to separate dioxins and dioxin like compounds into two fractions for quantitation. The samples will be passed through a multilayer silica column (column consists of H_2SO_4 impregnated silica gel, KOH silica gel and neutral silica gel) at first to remove any organic interferents or similar co-extractants. Then the eluent will be passed through alumina and carbon columns in series to remove similar mass interferences and to separate into dioxins and dioxin like compound fraction.

DEXTech Pure (A fully automated sample cleanup system supplied by LCTech, Germany) was used for the sample cleanup of both air and ash samples. The total run time of the instrument is 65 minutes.

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Fig 3: Automated Dioxin clean up system

2.1.4 Nitrogen Evaporator

The fractions obtained after cleanup requires volume reduction to as low as 200 microliters as the analytes of interest are present in low picogram levels. Nitrogen evaporator/concentrator supplied by M/s. FMS Inc., USA (fig 4) was used for concentrating the fractions to near dryness. The fractions were concentrated by simultaneous nitrogen purging and heating inside a contained atmosphere. Custom made concentrating tubes were used to perform the concentration/evaporation of the solvent to reduce it to 200µl. Continuous vacuum will be applied inside the container for expelling the evaporated solvent from the system. Purge flow and temperature can be controlled throughout the process. The instrument minimizes the losses due to the volatility of the compounds and nullifies the chances of cross contamination. Ultrahigh purity (UHP) nitrogen is used for the purging process.

Fig 4: Nitrogen Evaporator

2.1.5. Gas Chromatograph – Triple Quadruple Mass Spectrometer (GC-MS/MS)

A triple quadruple mass spectrometer (GC-MS/MS) is used for the quantification of dioxins and furans. Agilent Technologies Make 7890 Series gas chromatograph coupled to 7000C Quadrupole MS/MS was used for the study (Fig 5).

Fig 5: Gas Chromatography – Triple Quadruple Mass Spectrometer

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2.2 Standards, Chemicals and Solvents

All native dioxins and furans standards were procured from Cambridge Isotope Laboratories, Massachusetts, USA. C^{13} labelled mixture of dioxins (DF-LCS-C200) and cleanup standard spiking solution ($^{37}Cl_4$ - 2,3,7,8-TCDD) (Cat No: S13CSSA) were procured from Wellington Laboratories, Ontario, Canada. All high purity solvents such as toluene, hexane and dichloromethane were procured from Spectrochem, India. Keeper solvents such as nonane and isooctane were obtained from E-Merck, Germany.

2.3 Sampling of Air and Burned Residue

The ambient air sampling started at 9.0 am on 21st February 2020 and was operated till 9.30 am 22nd February 2020. Pre-weighed filter papers and pre-cleaned polyurethane foam plugs were placed in their respective compartments inside the sampler at the site before the start of sampling. The samplers were operated under generator power throughout and the generator has been refuelled every 3 hours. During the time of sampling there were no active fires in the dumpyard (fig 6). There were safety concerns and practical difficulties in placing the sampler as well as generator near to the large heaps of wastes, where any uncontrolled fire could harm the equipments. The ambient air sampler was kept about 100 meters away from the epicentre of fire (fig - 7a & 7b). The fire fighters were tilting and tumbling the smouldering of waste piles using JCBs and water was flushed extensively to curtain any resurfacing of fire. This has resulted in a comparatively clean ambient environment at the site than that of first two days and was very much free from soot and dust with respect to the 2019 incident, wherein the team could reach the site before the active fire and smoke subsided completely.

24 hour sampling as specified in the USEPA method TO-9 [10] was performed and the operation of samplers were stopped at 9.30 am on 22/02/2020. The air suction rates for the two samplers were in the range of 0.12 – 0.18 m^3/min and 0.15 - 0.20 m^3/min respectively. Total volume of air sampled was 208 m^3 and 237 m^3 respectively.

Apart from air samples, the residual ash from various points in the waste pile was also collected for analysis (Fig. 8a & 8b). Many areas of the waste heaps were not accessible due to safety considerations at the site. Residues were collected from 8 points and were reduced to 4 composite samples (appr. 100 g each) by conning and quartering considering the area of collection.

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Upon completion of sampling on 22nd February 2020, the samples were carefully packed and transported to Dioxin Research Laboratory, CSIR-NIIST for analysis and quantification.

Fig 6: Brahmapuram waste dumpyard

Fig 7 a & 7b: Air samplers positioned at the site

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Fig 8a & 8b: Collection of Ash and residue from the site

2. 4 Sample analysis & Quantification

2. 4. 1 Sample preparation

The analysis of the ash and air samples were conducted following the standard operating procedures NIIST-SOP-D-01 and NIIST-SOP-D-03 respectively. The ash samples were dried prior to extraction at 104 ^{0}C for 4 hours to eliminate moisture content. Dried sample was taken in a glass fiber thimble and is extracted in the Soxhlet apparatus for 16 hours at a rate of 5 siphons per hour with toluene as charging solvent. In the case of air samples, the PUF plug and filter paper was taken for extraction along with PUF cartridge rinsates. Mass labelled congener mixture of the native congeners under study (100-500 pg) was spiked on to the samples before extraction for the recovery calculation.

The extract obtained after the Soxhlet extraction was concentrated to 2-3 mL of toluene by using rotary evaporator. The sample cleanup and fractionation were carried out using DEXTech Pure Automated Dioxin cleanup system. 15 mL of the sample extract (2-3 mL of toluene concentrate mixed with 12-13 mL of n-hexane) was fed onto the sample loop of the system. Two fractions PCDD/Fs & NO-PCBs combined and NDL & MO-PCBs were collected separately from the DEXTech system in a concentrator tube and concentrated to near dryness using nitrogen evaporator.

2.4.2 Quantification of Dioxins and Furans

Agilent 7890B GC system coupled to an Agilent 7000C series triple quadrupole GC/MS system was used for quantification of dioxins and furans. The samples upon evaporation to near dryness was mixed with 20 pg labelled syringe/recovery standard before making it upto 200 µL. The syringe standard is used to gauge the performance of the instrument. Thus, the internal standard recovery studies will monitor the analyte loss during extraction & cleanup steps, while the syringe standard will monitor the instrumental performance. The GC-MS run conditions are as given in table 1.

GC Conditions	
Column	Agilent DB-5 MS UL, 60 m*250 um*0.25um Fused silica capillary column
Inlet	Programmed temperature vaporization inlet (PTV)
Outlet	Vacuum
Injection volume	4 uL
Injection port	Multi-Mode Inlet (MMI)
Injection port liner	Multi-baffle, deactivated PTV liner
Injection mode	Solvent vent
Vent flow	100 mL/min; pressure 5 psi
Purge flow	60 mL/min
Carrier gas	Helium
Carrier gas mode	Constant flow
Column flow	1.02 mL/min
Retention time locking	15.192 for TCDD
Oven program	60 ^{0}C (1 minutes) 30 ^{0}C/min to 270^{0}C (9 minutes) 2 ^{0}C /min to 310 ^{0}C (29 minutes) 10 ^{0}C/min to 325 ^{0}C (35.5 minutes)
Total run time	35.5 minutes

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MS conditions	
Operation mode	Electron ionization (EI), Multiple reaction monitoring (MRM)
Transfer line temperature	280 ^{0}C
Source temperature	330 ^{0}C
Quadrupole temperature	150 ^{0}C

Table 1: GC/MS run conditions

2.5 Calculations and Reporting

2.5.1 Toxicity Equivalence factor and Quantification and Recovery calculation

The PCDDs and PCDFs toxicity of a mixture is stated as TEQ (TCDD equivalents) and is equal to the sum of the concentration of individual congeners multiplied by their toxicity equivalent factors (TEF) [12].

$$\text{Total TEQ} = \sum[PCDDi \times TEFi] + \sum[PCDFi \times TEFi] \qquad (1)$$

The 2005 World Health Organization human toxicity equivalency factors for dioxins was used in the present study and is given in Table 2.

SL. No	Target Analytes (PCDD/ PCDF)	WHO-Toxic Equivalent Factor (WHO-TEF$_{05}$)
	PCDDs	
1	2,3,7,8- TCDD	1
2	1,2,3,7,8- PeCDD	1
3	1,2,3,4,7,8- HxCDD	0.1
4	1,2,3,6,7,8 – HxCDD	0.1
5	1,2,3,7.8.9 – HxCDD	0.1
6	1,2,3,4,6,7,8-HpXDD	0.01
7	OCDD	0.0003
	PCDFs	
8	2,3,7,8 –TCDF	0.1
9	1,2,3,7,8-PeCDF	0.03

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10	2,3,4,7,8-PeCDF	0.3
11	1,2,3,4,7,8-HxCDF	0.1
12	1,2,3,6,7,8- HxCDF	0.1
13	1,2,3,7,8,9- HxCDF	0.1
14	2,3,4,6,7,8-HxCDF	0.1
15	1,2,3,4,6,7,8- HpCDF	0.01
16	1,2,3,4,7,8,9- HpCDF	0.01
17	OCDF	0.0003

Table 2: Toxicity equivalency factors for dioxins and furans as per WHO2005

2.5.2 Calculation of RF & RRF of native and labelled compounds

Response factor (RF) is the ratio of area of the peak of a particular compound to its concentration or quantity. Relative response factor of native compound ($RRF_{(n)}$) is the ratio of response factor of native congener with respect to that of labelled congener (also called internal standard).

The relative response factor of labelled compound is the ratio of response factor of internal standards with respect to that of recovery or syringe standard. The recovery or syringe standard is used to quantify the instrument efficiency.

(a) $$RRF_{(n)} = \frac{A_x}{Q_x}\frac{Q_{is}}{A_{is}} \qquad (2)$$

(b) $$RRF_{(l)} = \frac{A_{is}}{Q_{is}}\frac{Q_{rs}}{A_{rs}} \qquad (3)$$

Where

Ax is the response (sum of two m/z's) of native compounds;

Ais is the response (sum of two m/z's) of corresponding internal standard

Ars is the response (sum of two m/z's) of recovery standard;

Qis is the amount of internal standard pg/mL;

Qrs is the amount of recovery standard pg/mL;

Qx is the amount of native component pg/mL.

The average relative response factor is calculated as

$$\overline{RRF} = \frac{1}{m} x \sum_{i=1}^{m} RRF_{(n)} \qquad (4)$$

Where

m is the number of standards (concentration levels);

n is the native component;

i is the calibration level.

The average relative response factor for labelled compounds is calculated as

$$\overline{RRF} = \frac{1}{m} x \sum_{i=1}^{m} RRF_{(l)} \qquad (5)$$

Where

m is the number of standards (concentration levels);

l is the labelled compound;

i is the calibration level.

2.5.3 Calculation of concentration of native congeners

The content component of interest is calculated by = $C_x = \frac{A_x}{A_{is}} \frac{Q_{is}}{DIV} \frac{}{\overline{RRF_{(n)}}}$ (6)

where

Cx is the content of the component of interest in ng/kg;

Ax is the response (sum of two m/z values) of native compounds in sample extracts

Ais is the response (sum of two m/z values) of corresponding labelled internal standard in sample extracts;

Qis is the amount of injected labelled internal standard pg/mL;

DIV is the calculation factor from concentration (pg/mL) to content on sample basis (ng/kg) = M/V, where

V is final volume in µl;

M = sample intake in g.

RRF(n) is the relative response factor of native congeners

2.5.4 Internal Standard Recovery

The recovery for the internal standards used is calculated by:

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$$\text{Percentage recovery (\%)} = \frac{A_{is}}{Q_{is}} \frac{Q_{rs}}{A_{rs}} x \frac{100}{RRF_{(l)}} \qquad (7)$$

where

Ais is the response (sum of two m/z's) of the internal standard in the sample;

Ars is the response (sum of two m/z's) of the recovery standard in the sample,

Qis is the Amount of internal standard pg/mL;

Qrs is the Amount of recovery standard pg/mL;

RRF(l) is the relative response factor of labelled congeners

2.6 Calculation of Exposure factor and Cancer risk

The estimated risk factors were calculated based on ATSDR Public Health Assessment Guidance Manual, 2005 document [13].

2.6.1 Inhalation Exposure

2.6.1.1 Daily inhalation dose

Daily dose emanating from the inhalation of contaminated air is calculated by,

$$D = \frac{C*IR*EF}{BW} \qquad (8)$$

Where, D – exposure dose (mg/kg/day)

C – contaminant concentration (mg/m^3)

IR – intake rate (m^3/day)

EF – exposure factor

BW – body weight (kg)

2.6.1.2 Hazard Quotient

The non-carcinogenic effect, hazard quotient is calculated by,

$$HQ = \frac{D}{RfD} \qquad (9)$$

HQ - hazard quotient (unitless)

D – Exposure dose (mg/kg/day)

RfD – Reference Dose (mg/kg/day)

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2.6.1.3 Chronic Exposure

The whole life exposure or the extended exposure risk from inhalation is calculated by using the chronic exposure (CE) values. Chronic exposure was calculated by multiplying the air concentrations (Cair, mg/m^3) of the chemical species with inhalation factor (IF, $m^{-3}kg^{-1}day^{-1}$).

$$CE = Cair * IF \qquad (10)$$

$$IF = \frac{IRinh*EF*ED*ET}{BW*AT} \qquad (11)$$

IRinh – inhalation rate per hour (m3/day)

EF – exposure frequency (days per year)

ED – exposure duration (years)

ET – exposure time (number of hours per exposure)

BW – body weight (kg)

AT – average time of carcinogenic exposure over a life time (25500 days).

2.6.1.4 Cancer Risk

Cancer risk is the product of chronic exposure with cancer slope factor or cancer potency and is calculated by,

$$Cancer\ risk = CE * SF \qquad (12)$$

SF- slope factor

IUR – inhalation unit risk values for PCDD/Fs and dl-PCBs (taken from A Lopez et al., 2020) [14].

$$SF = \frac{IUR*70*1000}{20} \qquad (13)$$

2.6.2 Dermal Exposure

2.6.2.1 Daily dermal dose

$$D = \frac{C*A*AF*CF*EF}{BW} \qquad (14)$$

Where, D – exposure dose (mg/kg/day)

C – contaminant concentration (mg/m3)

A – total soil adhered (mg)

AF – bioavailability factor (unitless)

CF – conversion factor (10^{-6})

EF – exposure factor (unitless)

BW – body weight (kg)

2.6.2.2 Hazard Quotient

The non-carcinogenic effect, hazard quotient is calculated by,

$$HQ = \frac{D}{RfD} \quad (15)$$

HQ - hazard quotient (unitless)

D – Exposure dose (mg/kg/day)

RfD – Reference Dose (mg/kg/day)

2.6.2.3 Cancer Risk

$$Cancer\ risk = \frac{C*A*DAF*F*ED*EF}{AT*BW} \quad (16)$$

C – Concentration (mg/kg)

A – total soil adhered (mg)

DAF – Dermal absorptivity factor

F – exposure frequency (days per year)

EF – event frequency (no. of times per day)

ED – exposure duration (years)

ET – exposure time (number of hours per exposure)

BW – body weight (kg)

AT – average time of carcinogenic exposure over a life time (25500 days).

The standard values used for the calculations such as inhalation rate (15.2 m^3/day), soil adherence (299 cm^2 for children and 326 cm^2), inhalation unit risk (38), bio-availability factor (1), dermal absorption factor (0.1) are taken from ATSDR Public Health Assessment Guidance Manual, 2005 document [13,15].

3.0 Results and Discussion

3.1 Levels of dioxins in ambient air and residual ash

SI No	Matrix	Concentration
1	Ambient Air	2.7 pg TEQ/m^3
2	Ambient Air	3.6 pg TEQ/m^3
3	Residue	84.3 ng TEQ/kg
4	Residue	79.8 ng TEQ/kg
5	Residue	93.3 ng TEQ/kg
6	Residue	99.7 ng TEQ/kg

Table 3: Observed levels of dioxins in air and residue sample

Table 3 shows the concentration of dioxins observed in two ambient air samples and four residual ash samples collected from the fire breakout site at Brahmapuram. It can be observed that the average concentration of dioxins in ambient air and residue were found to be 3.2 pg TEQ/m^3 and 89.3 ng TEQ/kg respectively.

To make the observed dioxin levels in the field samples (ambient air and residue) from Brahmapuram more meaningful and to generate more insights into the values generated, background ambient air dioxin levels at two reference points were also assessed and were compared with the present values. A control ambient air sample was collected by operating the High volume PUF sampler for 24 hrs inside CSIR-NIIST campus which is devoid of open burning activities. Another field blank sample was collected by carrying out the same procedure as above from Thakarapparambu street waste burning site in Thiruvananthapuram on a day when there was no open burning activity during or the previous day of sampling. Table 4 provides the dioxin levels in the control and field blank sample in comparison with the levels in ambient air collected from Brahmapuram during 2019 and present (2020) fire breakout incidents. The table shows that the dioxins levels in ambient air of the control site and that in European cities are quite closer, which indicates the appropriateness of the chosen control site.

From table 4, it is evident that the observed concentration in ambient air at Brahmapuram is 2.5 times and 16 times higher than the field blank and control site concentrations. However, the observed concentration at Brahmapuram 2020 was found to be 3 times lower than the levels during

2019 incident. It is presumably due to the fact that the sampling in 2019 incident was conducted while the active fires and heavy smouldering were prevailing in comparison to the present study where the sampling was started 8-10 hours after extinguishing of fires and the field has been flushed with considerable amount of water to prevent any resurfacing of fire. It is evident from the fact that the concentration of particulate matter observed during 2020 incident was less than one-third of that observed during the 2019 fire breakout as shown in fig – 9. The water spraying has an effect on the particulate content in the atmosphere as well and therefore a lowering of dioxin levels was expected in the ambient air. It has been reported that 70% of dioxins are emitted and dispersed as particulate bound and only 30% is propagated in the vapour phase. Water spraying will affect both the dispersion routes and must have caused the drop of dioxin levels in the ambient air. Therefore, it is emphasized that the observed comparatively lower ambient air concentrations do not lead to the conclusion that the total generated dioxin during the incident could be lower.

A similar lowering of dioxins was observed in the residual ash as well (refer Table 3). The observed average level of dioxins in residual ash during the Brahampuram 2020 incident (89.3 ng TEQ/kg) were found to be about half the concentration reported during 2019 (158.5 ng TEQ/kg). The plausible reasons for this decrease could be due to lower quantity of waste burned, the flushing of water onto the burned residues and most of the site has been tilled with bulldozers. All these might have resulted in dispersion of the pollutants due to mixing or turbulence.

SL. No	Sampling location	Date of Sampling	Average Observed Concentration (pg TEQ/m^3)
1	**Control Site (NIIST Campus)**	22/10/2018	0.2
2	**Field blank (Open burn site, Thakaraparampu)**	08/01/2019	1.3
3	**Brahmapuram** (fire accident 2020)	21/02/2020	3.2
4	**Brahmapuram** (fire accident 2019)	25/02/2019	10.3
5	**European Cities**	NA	0.3

Table 4: Comparative evaluation of dioxins ambient air concentrations

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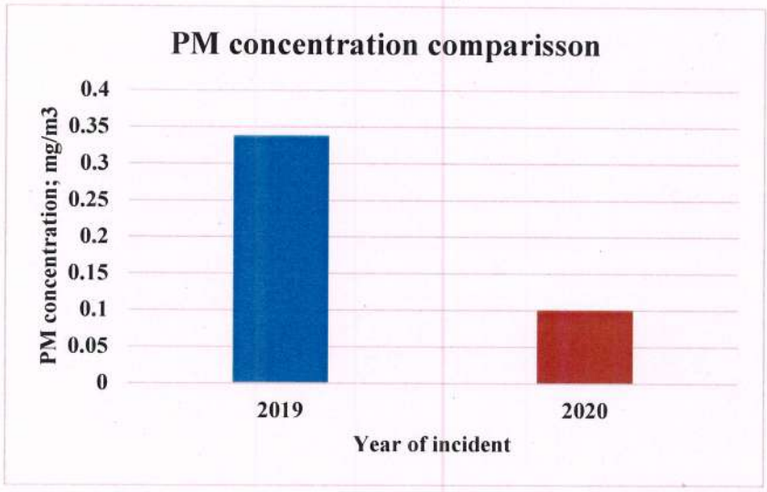

Fig 9: Particulate matter concentration comparison between incidents in 2019 and 2020

3.2. Method Performance by evaluation of internal standard recoveries

The analytical performance of the method was monitored by assessing the recovery of C^{13} labelled internal standards. As per standard methods, the recovery of internal standards of all the congeners of dioxins should be in the range of 60-120%. In case the recovery rate is less than 60%, the results are acceptable only if the particular congener's contribution to total toxicity equivalence (TEQ) is less than 10%. Table 5 and 6 shows representative internal standard recovery rate calculation sheet observed in an ambient air and residual ash sample in the present study. It can be observed that the recovery rates for majority of congeners are in the range of 60–120% and in case the recovery rates are not in the range percentage contribution is verified and those meeting the criteria was only included in the final calculation.

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Air sample analysis											
Spiked IS concentration (except OCDD & OCDF) Qis				500 ppt		**OCDD and OCDF concentration**			1000 ppt		
Spiked Syringe standard concentration						100 ppt					
Compounds	**Avg resp IS**	**Obt resp of IS**	**Syr std avg resp**	**Syr std obt resp**	**RF of IS**	**RF of Syr std**	**RRF of IS to Syr std**	**% Recovery**	**conc /g**	**TEF**	**TEQ**
2378-TCDF	82065.2	57206.6	46628.1	40339.0	164.1	466.3	0.4	80.6	1.5	0.10	0.15
2378-TCDD	26215.7	20295.0	46628.1	40339.0	52.4	466.3	0.1	89.5	0.7	1.00	0.66
12378-PeCDF	26895.4	23176.4	46628.1	40339.0	53.8	466.3	0.1	99.6	1.4	0.03	0.04
23478-PeCDF	27412.3	25745.4	46628.1	40339.0	54.8	466.3	0.1	108.6	1.5	0.30	0.45
12378-PeCDD	17351.8	15437.4	46628.1	40339.0	34.7	466.3	0.1	102.8	0.8	1.00	0.76
123478-HxCDF	30507.9	34128.4	18232.0	32045.0	61.0	182.3	0.3	63.6	0.9	0.10	0.09
123678-HxCDF	33290.8	34128.4	18232.0	32045.0	66.6	182.3	0.4	58.3	0.7	0.10	0.07
234678-HxCDF	31793.1	33314.2	18232.0	32045.0	63.6	182.3	0.3	59.6	1.0	0.10	0.10
123478-HxCDD	10406.4	11072.2	18232.0	32045.0	20.8	182.3	0.1	60.5	0.9	0.10	0.09
123678-HxCDD	10947.3	11072.2	18232.0	32045.0	21.9	182.3	0.1	57.5	0.8	0.10	0.08
123789-HxCDD	12757.5	12664.8	18232.0	32045.0	25.5	182.3	0.1	56.5	0.8	0.10	0.08
123789-HxCDF	27037.0	28713.1	18232.0	32045.0	54.1	182.3	0.3	60.4	0.8	0.10	0.08
1234678-HpCDF	29278.3	30641.5	15200.1	17542.0	58.6	152.0	0.4	90.7	1.7	0.01	0.02
1234678-HpCDD	11582.4	11097.8	15200.1	17542.0	23.2	152.0	0.2	83.0	2.4	0.01	0.02
1234789-HpCDF	26533.5	27279.1	15200.1	17542.0	53.1	152.0	0.3	89.1	0.7	0.01	0.01
OCDD	16041.5	14198.1	15200.1	17542.0	16.0	152.0	0.1	76.7	3.2	0.0003	0.0010
OCDF	24478.5	21235.7	15200.1	17542.0	24.5	152.0	0.2	75.2	2.3	0.0001	0.0002

Table 5: Recovery rate and TEQ calculation of air sample

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Residue Sample Analysis											
Spiked IS concentration (except OCDD & OCDF) Qis				500 ppt		**OCDD and OCDF concentration**				1000 ppt	
Spiked Syringe standard concentration						100 ppt					
Compounds	**Avg resp of IS**	**Obt resp of IS**	**Syr std avg resp**	**Syr std obt resp**	**RF of IS**	**RF of Syr std**	**RRF of IS to Syr std**	**% Recovery**	**conc/ g**	**TEF**	**TEQ**
2378-TCDF	82065.2	48149.8	46628.1	40339.0	164.1	466.3	0.4	67.8	113.5	0.1	11.347
2378-TCDD	26215.7	23302.9	46628.1	40339.0	52.4	466.3	0.1	102.7	6.4	1	6.362
12378-PeCDF	26895.4	24062.4	46628.1	40339.0	53.8	466.3	0.1	103.4	86.7	0.03	2.602
23478-PeCDF	27412.3	24996.2	46628.1	40339.0	54.8	466.3	0.1	105.4	95.0	0.3	28.513
12378-PeCDD	17351.8	14032.9	46628.1	40339.0	34.7	466.3	0.1	93.5	18.4	1	18.404
123478-HxCDF	30507.9	30012.5	18232.0	32045.0	61.0	182.3	0.3	56.0	37.0	0.1	3.696
123678-HxCDF	33290.8	30012.5	18232.0	32045.0	66.6	182.3	0.4	51.3	8.0	0.1	0.802
234678-HxCDF	31793.1	28005.9	18232.0	32045.0	63.6	182.3	0.3	50.1	50.4	0.1	5.036
123478-HxCDD	10406.4	16883.9	18232.0	32045.0	20.8	182.3	0.1	92.3	13.5	0.1	1.346
123678-HxCDD	10947.3	16883.9	18232.0	32045.0	21.9	182.3	0.1	87.7	15.7	0.1	1.569
123789-HxCDD	12757.5	16815.1	18232.0	32045.0	25.5	182.3	0.1	75.0	12.7	0.1	1.266
123789-HxCDF	27037.0	25587.8	18232.0	32045.0	54.1	182.3	0.3	53.8	14.5	0.1	1.446
1234678-HpCDF	29278.3	28725.5	15200.1	17542.0	58.6	152.0	0.4	85.0	112.1	0.01	1.121
1234678-HpCDD	11582.4	16867.0	15200.1	17542.0	23.2	152.0	0.2	126.2	62.2	0.01	0.622
1234789-HpCDF	26533.5	25165.8	15200.1	17542.0	53.1	152.0	0.3	82.2	9.4	0.01	0.094
OCDD	16041.5	18438.7	15200.1	17542.0	16.0	152.0	0.1	99.6	64.6	0.0003	0.019
OCDF	24478.5	23521.2	15200.1	17542.0	24.5	152.0	0.2	83.3	27.1	0.0001	0.003

Table 6: Recovery rate and TEQ calculation of residue sample

3.3 Congener Profiles

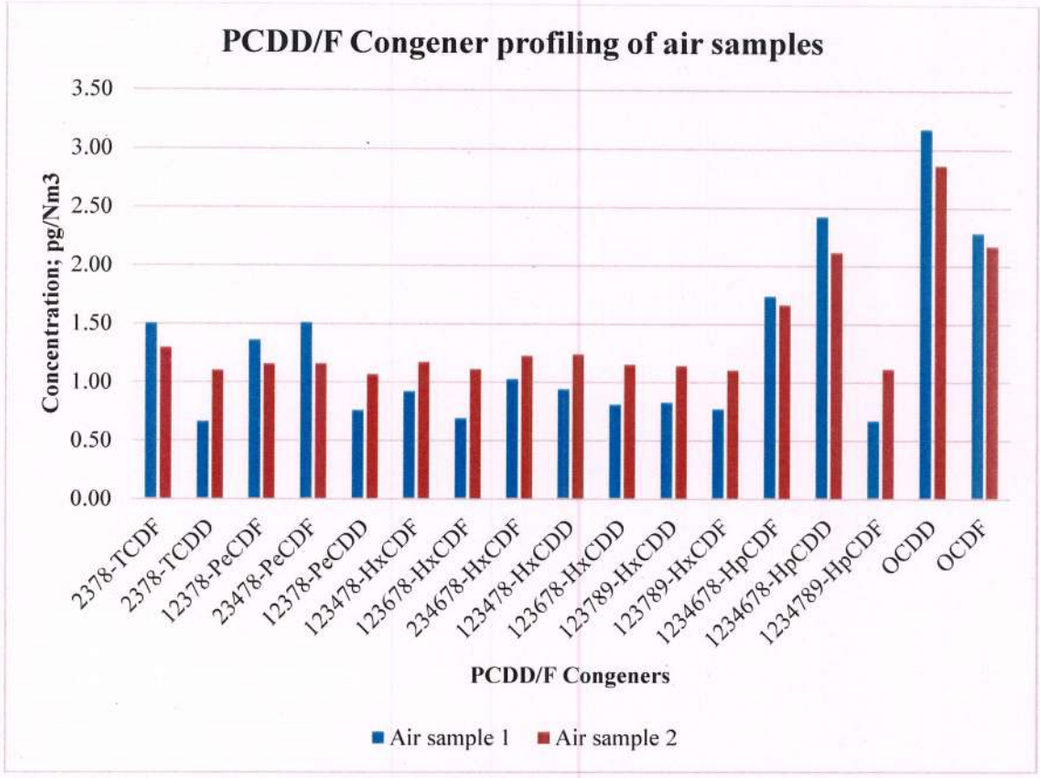

Fig 10: PCDD/F congener profiling in ambient air samples

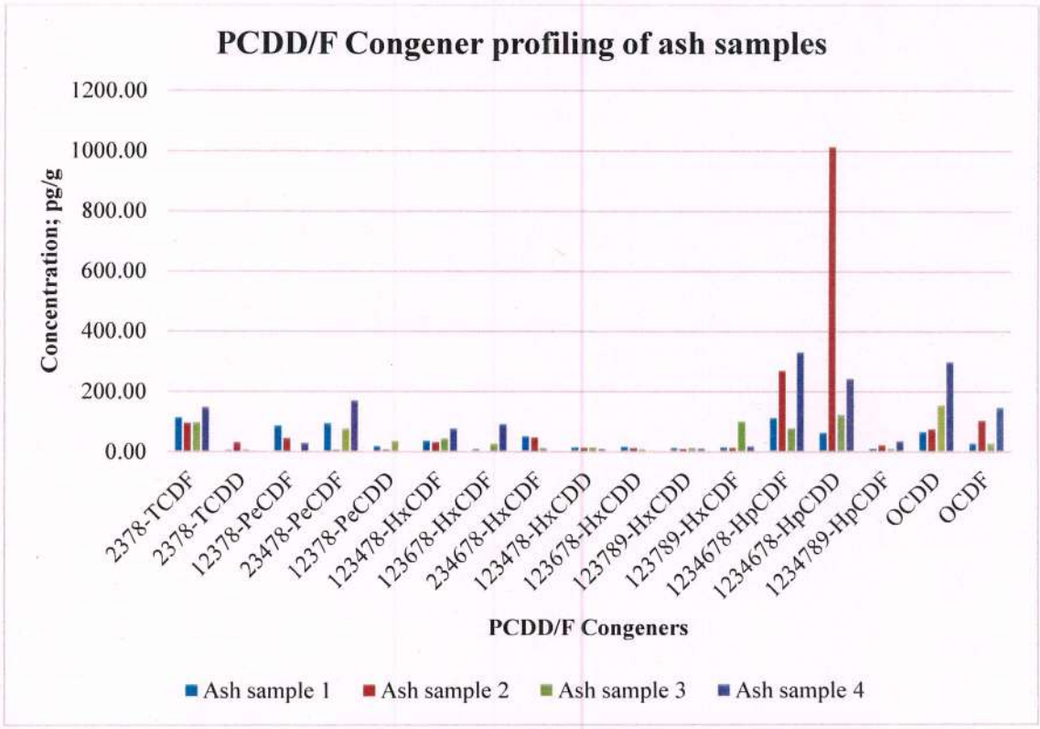

Fig 11: PCDD/F congener profiling in burned residue samples

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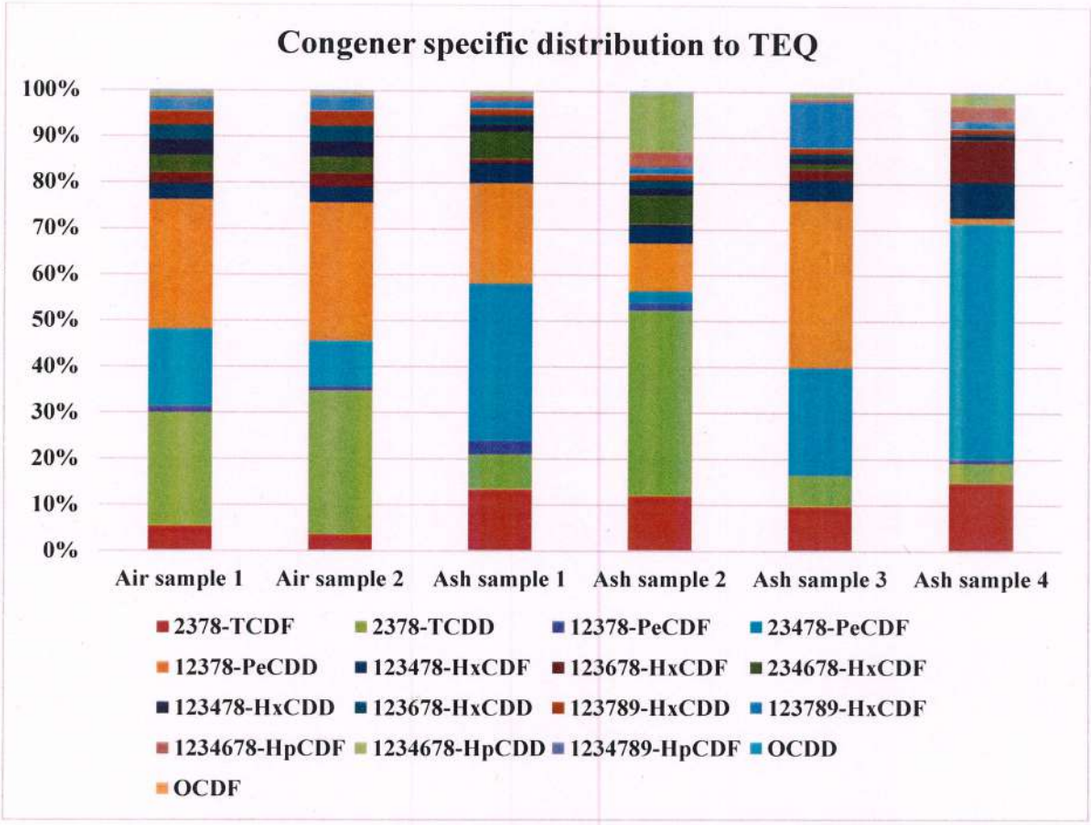

Fig 12: PCDD/F congener profiling with respect to TEQ for air, and residual ash samples

A comparative study on the observed levels of each dioxin congener on the basis of its contribution to total toxicity equivalence (TEQ) was also conducted. Fig 10, 11 and 12 shows the congener distribution profile in ambient air, residual ash and congener specific distribution to TEQ in air and ash samples. All the samples showed predominance of lower chlorinated dioxins and furans (tetra and penta) in terms of toxicity equivalence. TCDD (the known human carcinogen) the most toxic congener with WHO TEF value 1 was detected in all the samples. Hepta and octa chlorinated species were found to be particularly higher in all the samples. The mechanistic studies regarding the formation of dioxins suggest that the during combustion processes higher chlorinated forms will be the major product and with time de-chlorination will lead to formation of more stable lower chlorinated ones. The furan to dioxin ratio was found to be 1:0.8 in air samples and 0.8:1 in ash samples. More details on the dioxin formation tendencies during such an open fire breakout need deeper investigation on various critical parameters influencing the predominance of particular congeners such as the waste composition, temperature, oxygen levels etc. In fact it is extremely difficult to conduct such

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mechanistic investigation during onsite incidents. It requires simulated open burning studies as conducted by NIIST previously.

3.4 Comparative evaluation of present results with simulated waste combustion studies

The estimation of dioxins and furans levels in ambient air samples can only provide an indication of the presence of dioxins remaining in the air and it gets more and more diluted as the distance from the source of emission increases. It cannot be used for quantifying the total emission occurring from a point/area source. The onsite ambient air samples are directly linked to the atmospheric dilution effects, physical barriers in the sampling pathway, sampling point, wind direction and time etc. Accounting of all these factors at site and deducing total emission from such incidents is not feasible. In order to address this challenge CSIR-NIIST generated default emission factors of dioxins from the open burning of municipal solid wastes by conducting simulated waste combustion studies in a combustion chamber - Burn Hut, which is named as **Open Burn Test Facility (OBTF). Emission factor (EF) is the total quantity of dioxins emitted per ton of open burning of MSW in the present context**. The report study titled **"Determination of emission factors of dioxins from open burning of municipal solid wastes in Kerala"** had been submitted to Kerala State Pollution Control Board in December 2018. The reported emission factor was arrived from OBTF experiments using simulated waste samples (by mixing known composition and quantity of different components of waste). Further, the experts suggested to validate the results with sampled MSW as simulated samples will not be an exact representation of original waste. The study has been continued with 13 waste samples taken from 11 out of 14 districts across the state so as to arrive at a more appropriate default emission factor which accommodates the physical attributes of MSW in field. Two MSW samples from Thrikkakkara municipality and Brahmapuram MSW treatment centre were also been collected from Ernakulam district for the OBTF experiments. The samples from real field shown comparatively higher emission rates and finally, a default emission factor has been arrived based on the additional studies undertaken as **EFair – 67 µgTEQ/ton of waste, EFland – 100 ugTEQ/ton of waste and EFtotal – 167 µgTEQ/ton of waste**. The estimated default emission factor generated from a representative set of simulated combustion experiments was more realistic and showed strong positive correlation with waste compositions reported in major metropolitan cities of the country such as Bangalore, Mumbai, Delhi & Kolkata and hence it can be considered as a default national dioxin emission factor from open burning of MSW.

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The presently observed dioxin levels in residual ash (84.2, 79.8, 93.3, 99.7 ngTEQ/kg with an average of 89.3 ngTEQ/kg) was found to be quite closely matching with the emissions for residual ash obtained as a result of combustion experiments conducted at OBTF using Brahmapuram and Thrikkakkara MSW samples which is 95.3 and 97.4 ngTEQ/kg. However, the concentrations observed in ambient air samples was much lower compared to that of the OBTF experiments using the above mentioned MSW samples from Brahmapuram and Thrikkakkara due to the dilution effects and other physical barriers encountered in a field sampling. The concentrations observed in air based on the OBTF experiments with Brahmapuram and Thrikkakkara MSW samples were 104.8 and 51 pgTEQ/Nm^3 whereas the concentrations observed in the two ambient air samples in the present study is just 2.7 and 3.6 pgTEQ/m^3 respectively. It is again emphasized that the ambient air concentration observed during the incident cannot be compared to the concentrations obtained from simulated combustion studies at OBTF as the latter one obtained from the laboratory experimental set up is quantitative in nature than the former case. Hence, the total dioxin emission during the fire breakout incident was calculated using the default emission factors generated from OBTF experiments.

3.5 Total emission calculation

The total emitted quantity of dioxins during the incident can be calculated by multiplying "emission factor" with "activity rate". The "activity rate'' is the estimated quantity of MSW burned during the incident. The activity rate/quantity of waste burned during the incident was calculated based on the method followed in the previous report (Brahmapuram 2019). The total fire occurred area was calculated using satellite images obtained from M/s. Planet Labs (fig - 13). From the satellite images, it was calculated that a flat area of 11957 m^2 caught fire during the incident. A correction factor 1.5 was applied on the estimated area to compensate the changes in surface area due to uneven waste dumps and heaps on the surface. Also, as in the previous report, it was considered that a 20 cm deep burning occurred during the incident.

Hence, the volume of waste burned is obtained as 3587 m^3 and average bulk density of MSW in Kerala – 350 kg/m^3 was used to determine tons of waste burned. Hence the total quantity of waste burned was calculated as 1300 tons of dumped waste.

Total volume of waste burned = Fire breakout area X 1.5 X depth

Total quantity of waste burned **(Activity rate)** = Volume burned X Bulk Density

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Total dioxin emission = 'Emission Factor' X 'Activity rate'

The total calculated dioxin emission during the Brahmapuram fire breakout incident -2020 was found to be **221 mg TEQ.**

3.6 Revisiting and comparison of dioxin emission during Brahmapuram 2019 vis-à-vis 2020 fire breakout incidents

As mentioned in section 3.4, further studies were undertaken by NIIST to generate default emission factor of dioxins from open burning of MSW by conducting OBTF experiments using real dumpsite waste samples during 2018-2020. Upon completion of the study, the emission factor of dioxins to air was updated from 5.1 to **67 µgTEQ per ton of waste** and that in land has been updated from 34.71 to **100 µgTEQ per ton of waste** respectively. Hence the updated total emission factor is 167 µgTEQ per ton of waste burned instead of 39.81 µgTEQ per ton of waste burned reported previously.

Now, the present Brahmapuram 2020 fire breakout study considered the updated default emission factor for calculation the total emission. In addition, we have revisited the dioxin emission reported in the Brahmapuram -2019 report, based on the latest studies on the default emission factor from open burning of MSW. The previous report was based on the average emission factor of dioxins to air and land is 5.1 & 34.71 µg PCDD-F TEQ_{WHO}/ ton of original waste burned. **A comparative evaluation of the total emission during 2019 and 2020 incidents is provided in table 7.**

Hence, based on the updated emission factor, the total dioxin emission during 2019 and 2020 fire breakout incidents were calculated to be 306 and 221 mg Toxicity equivalence (TEQ) respectively.

Study information	Total Emission factor (µg TEQ per ton)	Estimated Air emission (mg TEQ)	Estimated Land emission (mg TEQ)	Total emission (mg TEQ)
Fire accident in 2019 (stated in previous report)	39.81	9.2	62.5	72.0
Fire accident in 2019 (revisited)	167	126	180	306
Fire accident in 2020 (Present study)	167	91	130	221

Table 7: Total generated quantity of dioxins at Brahmapuram during 2019 and 2020 incidents

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SOURCE: PLANET LABS

Fig 13: Satelite images of the Brahmapuram MSW plant on, before and after the fire breakout incident in February 2020

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3.7 Exposure and Risk Assessment at the Fire Accident Site

Dioxins are highly carcinogenic and mutagenic compounds and hence the non-carcinogenic and carcinogenic risks posed by the emission of these chemicals at the site were also studied. More than 90% of the dioxins exposure to humans occur through food. Since dietary exposure was not under the purview of this study, this major pathway is not evaluated. The second and third major pathways – risk due to inhalation and dermal absorption were analysed in this study and is reported here.

3.7.1 Daily Exposure Dose (DED)

Daily exposure doses are the average mass of the contaminant that can get adhered to the body of the person who got in contact with the contaminant. Daily exposure doses are expressed in mass of the contaminant exposure per unit body weight per day (pg kg^{-1}b.w.day^{-1}). As per ATSDR guidelines the daily exposure doses through inhalation and dermal routes should be calculated with the highest concentration observed at the site. Hence burned residue levels reported in 2019 – 158.24 pgTEQ/g and ambient air levels – 10.3 pgTEQ/m^3 were used for calculating daily doses as well as risk factors. 2-5 small- and large-scale fire incidents are reported at the dumpyard site every year. The atmospheric lifetime of dioxins is reported to be 5-6 days and assuming fire during each incident persisted for one day, frequency of the exposure is taken as 6 days per incident. Hence the total exposure duration was calculated as 30 days considering 5 incidents to be frequency per year. The first fire incident at Brahmapuram was reported in 2010 and hence till 2020, the cumulative exposure duration of 10 years has been taken for dose calculations. Two age groups were considered for the present study – Children, from age 1-16 with an average body weight of 50 kg and adults from age 17-70 with an average body weight of 70 kg. The DEDs from inhalation exposures were estimated as per the equations 8 as 1.59×10^{-9} mgTEQ kg^{-1}bw day^{-1} for children and 3.54×10^{-9} mgTEQ kg^{-1}bw day^{-1} for adults. In the case of dermal exposures, the burned residues might remain on the outer layer of the dumpyard for 2-3 months until it gets subsided by the new dumping of waste as no collection of residual ash mechanism is present at the site. Hence the exposure frequency per year is calculated as 90 days and the cumulative exposure duration is taken as 10 years. The DEDs arising from dermal exposures were estimated based on equation 4, as 1.46×10^{-11} mgTEQ kg^{-1}bw day^{-1} for children and 3.49×10^{-12} mgTEQ kg^{-1}bw day^{-1} for adults.

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3.7.2 Non-carcinogenic risk assessment

Non-carcinogenic risk associated with the exposures for adult and children were expressed as hazard quotient (HQ). The DEDs were compared with tolerable daily intake values (1-4 pgTEQ $kg^{-1}bw\ day^{-1}$) set by World Health Organisation (WHO) to determine the hazard quotient values. The threshold value of HQ is 1 and where HQ < 1 indicates lower exposure than no observed effect dose and is considered as safe. The HQs were estimated for inhalation and dermal routes separately based on equations 9 and 15 (table 8). The HQ values were very lower for both the age categories through both the routes than the threshold value indicating non-carcinogenic risk at the site was minimal. The cumulative non-carcinogenic effect from both the routes is termed as Hazard Index (HI) and also found to be much lower than the threshold value of 1.

Category	HQ dermal	HQ Inhalation	HI
Children	0.004	0.04	0.044
Adults	0.0009	0.009	0.009

Table 8; Non-carcinogenic risk factors for children and adults at Brahmapuram due to dermal and inhalation exposure to PCDD/Fs.

3.7.3 Carcinogenic risk

Carcinogenic risks at the site were evaluated through incremental lifetime carcinogenic risk (ILCR) considering the exposures through dermal and inhalation routes (table 9) as per the equations 12 and 16.

Category	Dermal exposure	Inhalation exposure	Cumulative
ILCR	5.45×10^{-07}	6.19×10^{-06}	6.74×10^{-06}

Table 9; Incremental lifetime cancer risk factors at Brahmapuram due to dermal and inhalation exposure to PCDD/Fs

The ILCR values are classified as values $\leq 1\times10^{-6}$ correspond to very low, $1\times10^{-6} - 1\times10^{-4}$ are low; $1\times10^{-4} - 1\times10^{-3}$ are moderate; 1×10^{-3} - 1×10^{-1} are high and values > 1×10^{-1} represents very high risk (ATSDR Public Health Assessment Guidance Manual 2005). Concern over cancer risk arises when the estimated risk reaches 1×10^{-6}, and is considered as the action level. The inhalation exposure at the site exceeded the action level of 1×10^{-6} indicating that a low level of cancer risk persists to the exposed community at the site due to PCDD/Fs emission from accidental MSW open fires.

3.7.4 Carcinogenic risk projections

Four scenarios were further tested based on the ground level concentrations observed at the site.

Scenario 1 – exposure frequency is doubled (60 days) and the exposure duration (10 years) kept constant.

Scenario 2 – exposure frequency is kept constant (30 days) and the exposure duration (15 years) raised 1.5 times.

Scenario 3 – exposure frequency is doubled (60 days) and the exposure duration (15 years) raised 1.5 times.

Scenario 4 – exposure frequency is doubled (60 days) and the exposure duration (20 years) also doubled.

The results are as shown in the fig 14. It can be observed that increase in exposure factor or duration can significantly affect the ILCR of the exposed community. In the first projection where duration was kept the same and frequency was doubled an ILCR value in the range of 1×10^{-5} was observed. This value indicates that 1 additional person per one lakh people of the exposed community can develop carcinogenic effects in lifetime. When both exposure frequency as well as duration is doubled ILCR crossed 2.5×10^{-5} closing to the unacceptable level of 1×10^{-4}. ILCR of 1×10^{-4} indicates that 1 additional person out of 10000 people of the exposed community can develop carcinogenic effects over lifetime and is considered unacceptable by USEPA. Therefore, restoration of the site is highly recommended as accidental fires are inevitable in MSW dumpyards due to its unscientific structure. Even though the factors observed presently at the site is below 1×10^{-4}, considering the study limitations such as the absence of ingestion exposure data (through animal origin food consumption in the region), exact number of incident days, dioxins depositional flux at the site and the rate of other dispersal mechanisms the actual cumulative cancer risk could be higher than those calculated in the present study.

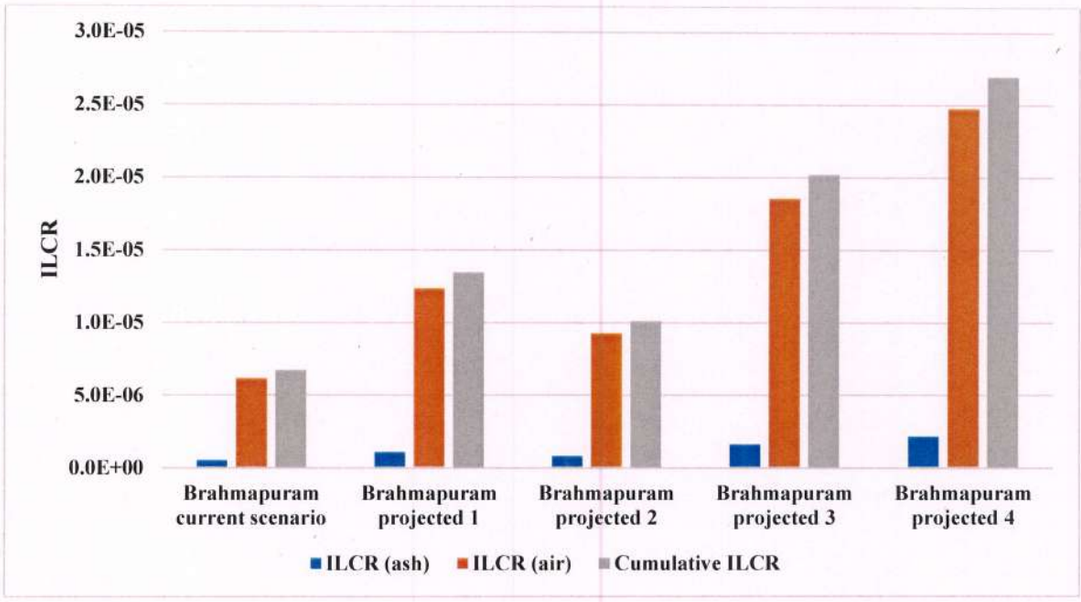

Fig 14; Graph showing the carcinogenic risk factors at the site currently and the four projected scenarios

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4.0 Summary

The waste dump at Brahmapuram caught fire during afternoon hours of 18/02/2020 and the fire was brought under control on 20/02/2020. CSIR-NIIST conducted the ambient air and burned residue sampling at site during 21- 22nd February 2020.

The major findings of the study are:

1. The average dioxin levels observed in the ambient air was found to be 3.2 pg TEQ/m^3 of air, which is 2.5 and 16 times higher than field blank and control site measurements respectively.

2. The average residue level observed at the site was 89.3 ngTEQ/kg of residue and is comparable with respect to the results from the simulated combustion studies at OBTF conducted by CSIR-NIIST using the original wastes from the site.

3. There were no active fires or fumigation during the hours of sampling and the field has been showered with water to contain further fire incidents. This could have significantly impacted the particulate emission levels in the ambient atmosphere as the concentration observed during this study is one-third of the 2019 study.

4. The total quantity of the dioxins produced from this incident was calculated using the updated default emission factor (167 µg TEQ/ton of waste) generated through the simulated combustion studies conducted by CSIR-NIIST. The total generated quantity of dioxins during the Brahmapuram 2020 incident was found to be 221 mg TEQ.

5. The dioxin emission occurred during 2019 fire breakout incident has been revisited based on the updated default emission factor and the updated total emission was found to be 306 mg TEQ.

6. Hepta and octa chlorinated congeners were found to be the major species in all the samples but the formation mechanisms are not clearly understood due to the lack of data on compositions, combustion temperature, available oxygen levels etc.

7. PCDD/Fs daily exposure doses (DEDs) to the exposed community through dermal and inhalation pathways were estimated with the highest ground level concentrations observed based on the ATSDR Public Health Guidance Manual for two age groups – Children (1-16 years) and adults (17-70 years).

-70-

8. The combined DEDs (dermal and inhalation pathways) for children and adults were 1.74×10^{-10} and 3.89×10^{-11} respectively. Hazard quotients and hazard index at the site were found to be much lower than the threshold value indicating minimal non-carcinogenic risk to the exposed community.

9. Incremental lifetime cancer risk (ILCR) was also estimated and found that the risk factor at the site is above the action level of 1×10^{-6}. This indicates a low level of cancer risk persists at the site due to the PCDD/Fs emissions from accidental MSW open fires.

10. 95-97% of dioxins exposure to humans occurs through ingestion pathway (through food) and only 3-5% occurs through inhalation and dermal pathways. As ingestion route was not assessed in the present study the risk factors at the site is expected to be higher than that estimated in the current report.

5.0 Recommendations

1. In view of the periodic fire breakout incidents reported at the site, it is evident that the surrounding environment would have been contaminated with higher levels of dioxins and furans compounds and an in-depth study comprising soil, sediment, water and air in the buffer zone of the dumpyard is essential to understand the fate in the environment.

2. An extremely important aspect to be addressed is the assessment of ingestion exposure via food chain, which was recommended in the 2019 report as well. More than 90 % of human exposure to dioxins and furans occurs via food chain especially through animal origin food samples due to the highly lipophilic nature of these contaminants. The decade old history of fire breakout incidents must have resulted in the contamination of nearby vegetation and human settlement areas. It will definitely result in exposure to the free ranging hens, cows and any other animals grazing in the area and also to the fishes in the nearby streams or ponds. Human exposure mainly occurs through the consumption of bio-magnified animal origin products such as eggs, milk, fish, meat etc. A systematic study of the levels of dioxins in animal origin food samples from the surrounding region is highly recommended to predict the health risk of consumption. In fact, CSIR-NIIST has strong expertise and is accredited by NABL as per ISO/IEC 17025: 2017 for analysis of dioxins and furans in food and feed samples.

3. In addition, the major recommendation provided in the 2019 report is strongly reiterated. It is extremely important to establish a modern solid waste treatment plant to manage the incoming wastes. The legacy wastes in dumpyard need to be disposed by 'bio-mining' to separate combustible and inert material in a phased manner. The contaminated ash separated during bio-mining should be removed to sanitary landfill. A road map for installing modern waste treatment plant and the phased reclamation of site may be laid down and implemented at the earliest.

6.0 Reference

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ANNEXURE-R (SERIES)

Photographs taken during the inspections conducted by the Board Officials in connection with Brahmapuram Fire Breakout

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Date: 03.03.2023

Date: 04.03.2023

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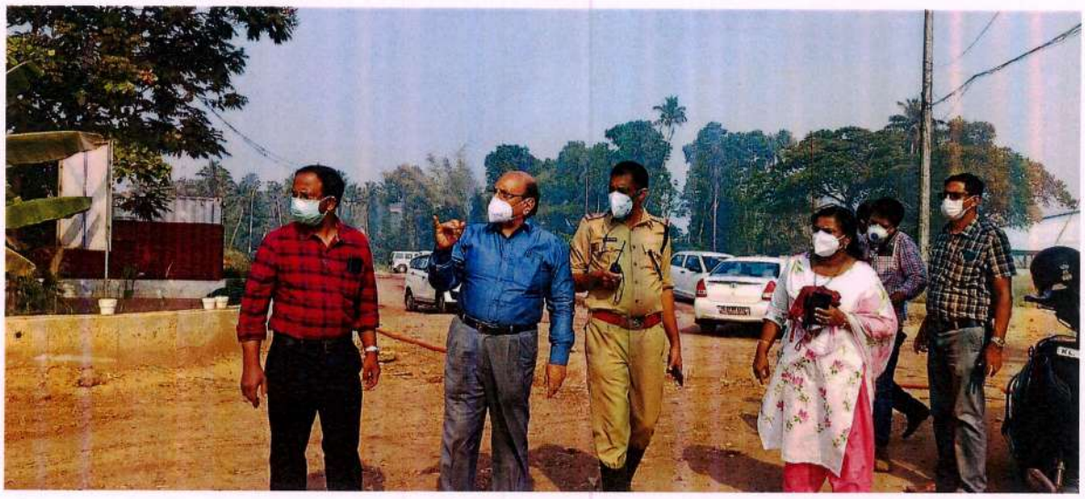
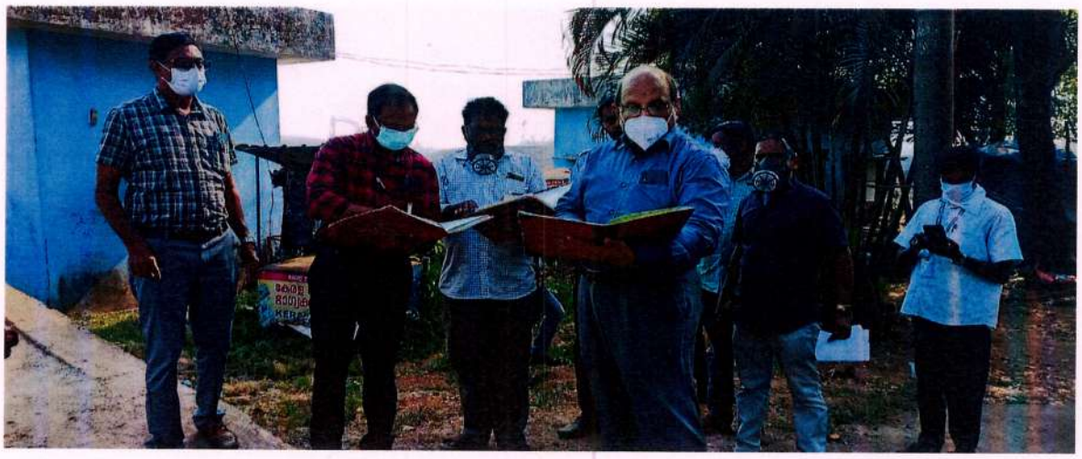
Date: 06.03.2023





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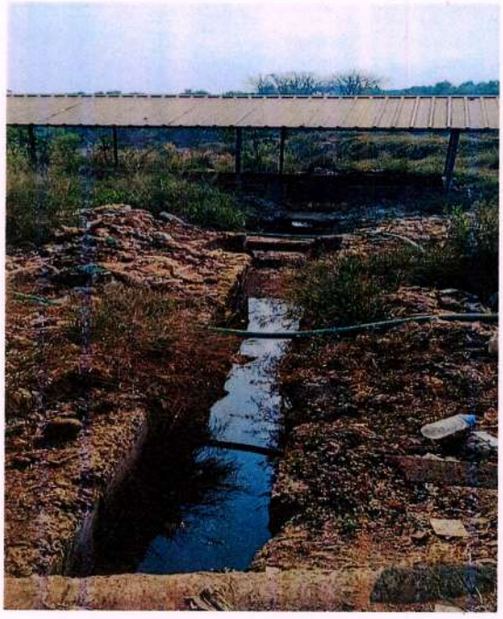
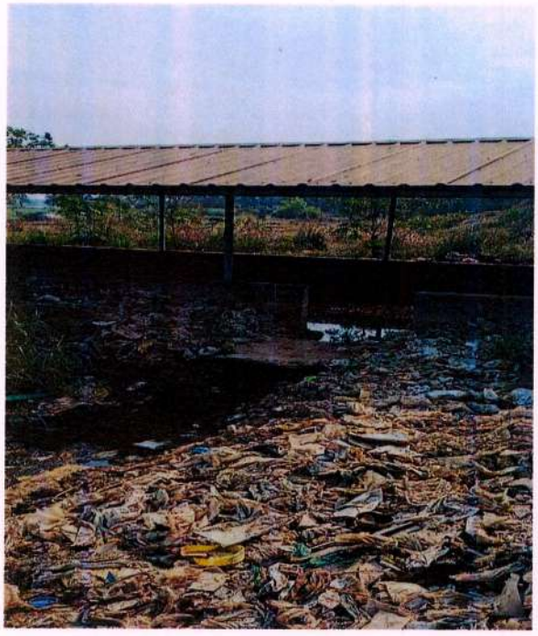
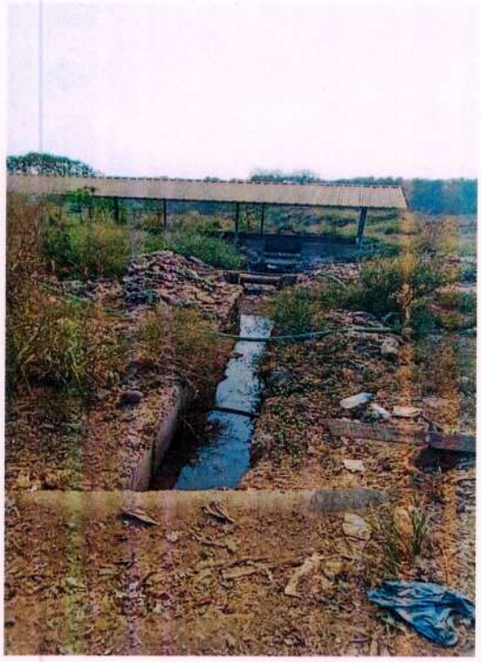
HYUNDAI







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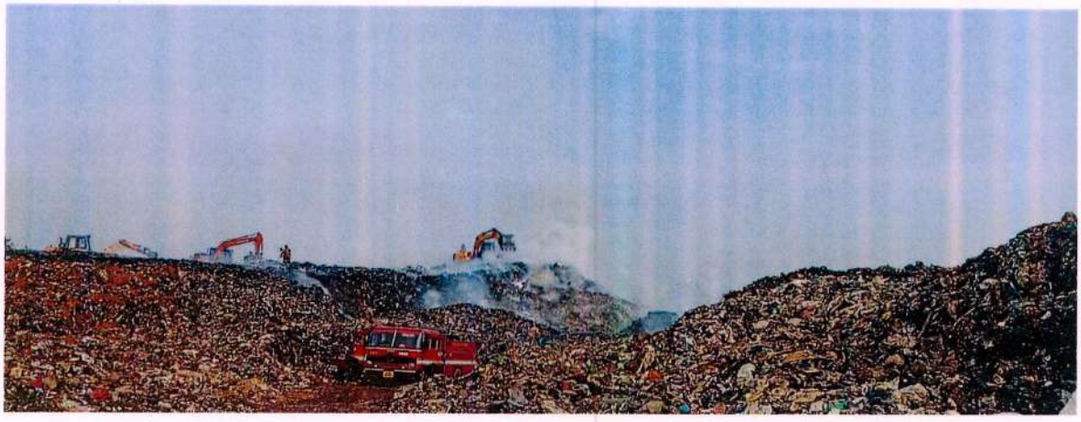
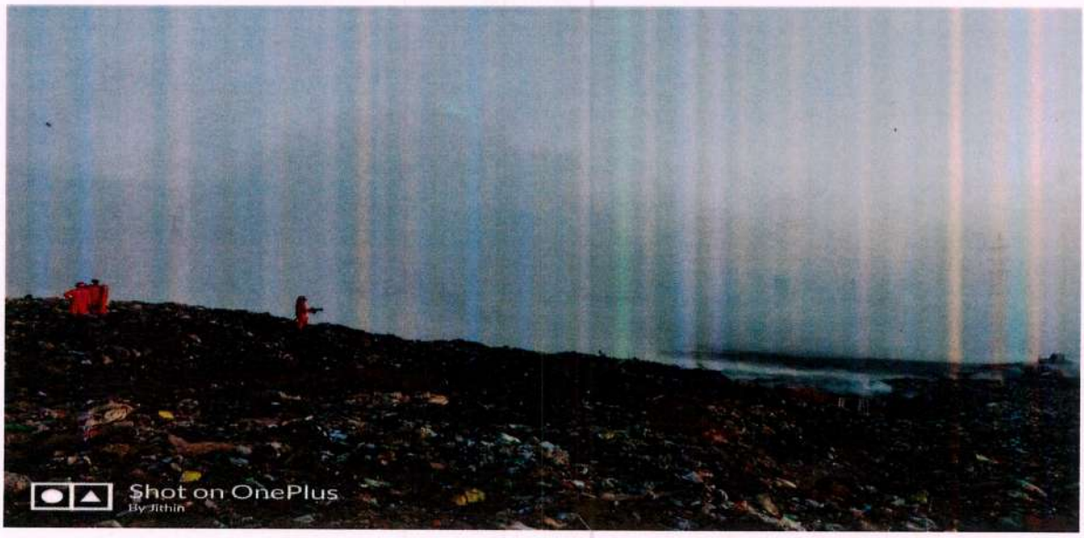



FIRE FIGHTING LARGE MK-VI
INISTRY OF DEFENCE
INS GARUDA


Shot on OnePlus
By Jithin


Shot on OnePlus
By Jithin


Shot on OnePlus
By Jithin


Shot on OnePlus
By Jithin


Shot on OnePlus
By Jithin


Shot on OnePlus
By Jithin

Date: 08.03.2023

Date: 09.03.2023