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LEVELS OF POLYCYCLIC AROMATIC HYDROCARBONS IN AN ABANDONED DUMPSITE SITUATED IN RUMUOLUMENI, PORT HARCOURT, RIVERS STATE, NIGERIA

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Abstract
This study measured the level of polycyclic aromatic hydrocarbons (PAHs) in an abandoned dumpsite situated in Rumuolumeni, Port Harcourt, Rivers State Nigeria. Soil samples from abandoned dumpsite were collected at three different points ascertain the strength of polycyclic aromatic hydrocarbons. The levels of the polycyclic aromatic hydrocarbons at the different points within the studied dumpsite were examined after elementary laboratory pretreatments were done and sample extraction for PAHs was attained using dichloromethane as solvent which was then followed by column chromatography clean up. Gas chromatography-mass spectrometer (GC-MS) was used in the analysis and determination of the concentrations of PAHs in the investigated soil samples obtained from the abandoned dumpsite. The mean levels of total PAHs within the different points during the time of study ranged from 0.0211 to 0.9792 mg/Kg with an average level of 0.6161±0.521 mg/Kg within the dumpsite under investigation. The values of total PAHs obtained within the dumpsite investigated were far below the 10 mg/Kg requirements for soils by both national and international bodies. Source identification to verify PAHs source indicated more of pyrogenic than petrogenic sources and that 4-6 membered ring PAHs were more in abundance when compared to 2-3 membered ring PAHs. The results recorded indicated PAHs contamination and therefore proper control and monitoring is required in order that the values will not increase to the point that soil around the studied area will be so degraded that can affect humans that assess the area where the dumpsite is situated.

Keywords: Anthropogenic activities, contaminated soil, dumpsite, PAHs, wastes.

INTRODUCTION

Human activities have brought about indescribable increase on the level of contamination of the soil, such contamination and pollution have brought about definite challenges in life that is aggressive to humans, animals and plants. These anthropological actions include the use of insect repellent and manures/plant stimulants, release of manufacturing wastes, mining, manufacturing of goods and services and also the breaking of storage tanks (Seifi et al., 2010). These identified activities has brought about notable fluctuations in the natural physical and chemical status of the soil environment. These variations in the nature of soil due to contamination sometimes results in the blocking of air spaces that offers air to the soil through diffusion from the pores of the soil particles (Sutton et al., 2013) thus creating alterations in the physical properties of the soil by varying the penetrability and Waterberg limit of the soil (Nazir et al., 2011; Akunwumi et al., 2014; Devatha et al., 2019). The progression and improvement of floras and other soil creatures are significantly altered which could be as a result of the adjustment in the biochemical behaviour and nature of the soil, namely; pH, total carbon-based compounds and inorganic nutrients (Yalin et al., 2006; Akubugwo et al., 2009; Wang et al., 2010). The continuous deficiency of these physical and chemical necessities is hostile and yields dangerous concerns that could lead to impropriety in soil situations and might also result in poor crop development and growth.

The contamination of soils due to waste dumping have given rise to environmental deterioration, decline and degrading by changing completely the nutrient, organic and elemental composition of the natural soil. The resulting consequences of waste dumping that is not controlled in the cities has triggered serious environmental contamination and has affected the natural/background level of the physiochemical properties and nature of the soil within the area used for the dumpsites. Soil contamination due to free-for-all dumping of waste in the surroundings has a consequential effect on the food chain and food safety and might prove to be unsafe to human health and general wellbeing. There is the possibility or likelihood of transfer of notable chemical species present in wastes to crops planted near to or within these areas selected as dumpsites which can eventually find its way into human beings (Nwoke & Edori 2020).

The adulteration of the environs is largely from humanoid undertakings, which could be either technologically advanced or agrarian production. Various environmental waste product and noxious compounds are released as waste in contempt to lay down guidelines and rules into the environment on daily basis (Inobeme et al., 2014). The main challenges which are in in agreement with residential increase, spread and industrial development in the midst of little income countries is pitiable hygiene conditions amongst the local inhabitants (Musa, 2014). Agreeing with Ubwa et al. (2013) the waste so created from dissimilar anthropoid activities might be one or the other beneficial or injurious to the environs which could also be dangerous or hazardous to floras, faunas and lastly man the final consumer. Contributions from individually from industry and social output are likely and conceivable pathways of unalterable responses in the atmospheric milieu and as a result can effectively hamper progress (Sharma et al., 2014). The environment is restricted in its ability to hold these noxious waste and also conditional on other environmental dynamics. Even though some ecological systems be able to hold or transfer some toxins to a substantial level, others can be at risk to such hostile concerns.

Temporarily and permanent dumpsites abound in Port Harcourt, where refuse from homes, commercial centers, industries and other public places like motor parks, hospital and schools are dumped on daily basis and the need to adequately document the levels of contamination by polycyclic aromatic hydrocarbons become very necessary. There are many abandoned dumpsites all over the city of Port Harcourt, most of these dumpsites are close to farm lands and during rainfall, or by migration there is flow from these abandoned dumpsites into these farmlands. The regular contact of these parameters by humans, animals and plants effect their ecology. There are diverse types of abandoned wastes that abound in the waste dumpsites. These wastes effect the overall ecology of the environment and the total ecosystem. Abandoned dumpsites is a common place for planting of crops and vegetables which possibly can pose health hazards on the individuals that consumes these crops and vegetables. The contaminants in the dumpsites soil could bio transfer from soil to crop and can also creep underground to contaminate groundwater, rendering it unhealthy. Moreover, persons live nearby to these abandoned dumpsites, which could pose health concern. It is therefore imperative to estimate the level of polycyclic aromatic hydrocarbons in the abandoned dumpsites in Rumuolumeni, Port Harcourt.

MATERIALS AND METHODS

The study area

The study site is located at the Ignatius Ajuru University of Education (IAUE) in Rumuolumeni, Port Harcourt, Rivers State, Nigeria. The dumpsite is located at the south-west of the Rumuolumeni Community and measures about 5km2. The area has been heavily impacted by pollutants from the dumpsite. The sampling points were carefully chosen from three locations: Location 1 - Location, which were some degrees and distances away from each other. These positions were intentionally picked on the basis of physical look of the land and the pecuniary activities from place to place in the area.

Collection of soil samples

Soil samples were composed at random from three points from the abandoned dumpsites in IAUE, Rumuolumeni, Port Harcourt with soil auger. The samples were composed at three different positions within a particular sampling site or scene and then appropriately mixed composed to form a composite sample. After each sampling, the auger was washed thoroughly with water and allowed to dry so that the samples from one location does not impact on another location. Polythene bags that were already labelled were used in preserving the samples before being conveyed to the laboratory for pre-treatment and more treatments before inquiry and determination of the concentration of PAHs in the soil of the out of use dumpsite.

Preparation of soil samples for polycyclic aromatic hydrocarbons analysis

The method employed by Prycek et al. (2007) was adopted in preparing and extracting PAHs from the soil for determination. Soxhlet extractor with 125ml of methanol was employed in the extraction of soil samples for 4 hours. 250ml of dichloromethane was added into the content after it was allowed to cool and extraction allowed to continue for 24 hours after adding dichloromethane. The extracts were filtered into a 500ml capacity separatory funnel. Then the extract was eluted using a 250ml funnel into a beaker and was purified further by washing thrice in a 50ml beaker that contain dichloromethane solvent. The extracted portion was the placed in a rotary evaporator to reduce the quantity to about 5 cm3. The sample was further purified by putting the extract into a 50ml capacity round bottom flask, and then 15 ml of n-pentane was again added. The sample was further reduced via evaporation to about 2ml with the aid of a rotary evaporator. A stream of N2 gas was at that juncture used to further reduce the n-pentane extract by the evaporator to 0.5ml so as to allow easy passage through a column of activated silica gel packed with slurry for about 8 hours at 200 oC. Water was totally removed from the extract by allowing the extract pass a packed column that is dry and cleaned previously using anhydrous sodium sulphate. Saturated hydrocarbons were first separated and eluted with the addition of n-pentane and then PAHs were finally eluted with the addition of 14% CH2Cl2.

Gas chromatography-mass spectrometry conditions

The Prycek et al. (2007) technique was adopted in this study. The Agilent 6890N chromatograph model gas chromatography-mass spectrophotometer, with serial No. US 10530055 (Agilent Technologies Avondale, USA) was used in determining the level of PAHs present in the pretreated samples. The equipment was attached to a mass detector model 5975 series MSD, Agilent, Avondale, USA. The separation of the diverse PAHs components was obtained by the use of a 5% phenyl-methylsilicone (DB-5MS) segment attached to a fused-silica tube column with dimensions 30 m X 250 µm ID and film thickness of 0.25 µm. The tube column was carefully chosen with part number 19019J_413 and worked at a hotness range of -60 to 350 oC. The injector port was wrought in split less manner. The kiln hotness was kept at 65 oC for an interval of one minute and was later increased to 290 oC at a stable frequency of 10 oC/min and was then steadily maintained at 290 oC for a period of 11 minutes. The line used for the passage of the extract was maintained at a temperature of 300oC. The stock solution was employed in the estimation of the retention time for every PAHs analyte. The heights gotten from the probe type were then utilized in detecting and measuring the ion heights and to locate or identify the various PAHs in the samples. Helium was the carrier gas used and was sustained by nitrogen gas for the gas chromatography. The system was kept and run at a pressure of 9.0855 Psi at 37.604 cm/sec as flow rate.

Diagnostic ratio assessment and source identification of polycyclic aromatic hydrocarbons

To understanding the origin or determining the apportionment, sources or input of PAHs into the soil of the abandoned dumpsite, provable diagnostic ratios or relations were utilized to institute the probable sources of PAHs in the soil investigated. The source identification relationships employed in ascertaining the input sources of PAHs into the soil under investigation are:

Fluoranthene/Fluoranthene + Pyrene ratio (Flu/ Flu + Py), Anthracene/Anthracene +Phenanthrene ratio (An/ An + Ph), Benzo [a] anthracene/ benzo [a] anthracene + chrysene ratio (BaA/BaA + Ch) and LMW/HMW ratio. These ratios or indices are vital in categorizing and diagnosing the origin and sources of the hydrocarbon occurrence and pollution in the environment (Ilechukwu et al., 2016).

Once the estimated ratio of lower molecular weight PAHs (LMW) to that of highew molecular weight PAHs (HMW) becomes higher than one (LMW/HMW >1), the origin or input is possibly from petrogenic source of origin and values obtained that are lower than one possibly originated or come from pyrogenic sources or orgin. When the ratio of anthracene/ anthracene + phenanthrene (An/ An +Phe) calculated is lower than 0.1 it reveal petrogenic source or origin of PAHs whereas when the calculated ratios is more than 0.1 it shows an input source from pyrogenic origin. In considering the higher molecular weight PAHs, when the estimated ratio concerning Fluoranthene / Fluoranthene + Pyrene (Flu/Flu+ Py) is above 0.5 it showed input of pyrogenic sources, but when the ratio calculated is below 0.4, it show an indication of origin from petrogenic sources. More identification ratio was accomplished by calculating the proportion of benzo [a] anthracene/ benzo [a] anthracene + chrysene (BaA/ BaA + Ch). When this ratio is lower than 0.2, it reveal origin of petrogenic input, but when the ratio is more than 0.35, it shows that it originated probably from pyrogenic sources of origin.

RESULTS AND DISCUSSION

Levels of polycyclic aromatic hydrocarbons in the abandoned dumpsite

The results recorded for the levels of the dissimilar constituents of PAHs at the different points in the abandoned dumpsite in Rumuolumeni, Port Harcourt are given in Table 1.

Table 1: Levels of polycyclic aromatic hydrocarbons at an abandoned dumpsite

PAHs (mg/Kg)	Stations			Mean
	1	2	3	
Naphthalene	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND
Acenaphthene	ND	ND	0.0004	0.0001±0.000
Fluorene	ND	0.0081	0.0012	0.0031±0.004
Phenanthrene	0.1969	ND	0.0027	0.0665±0.113
Anthracene	ND	0.0116	0.0105	0.0040±0.007
Fluoranthene	ND	0.0078	0.0018	0.0029±0.001
Pyrene	ND	0.0390	ND	0.0130±0.010
Benzo(a)anthracene	ND	0.0696	0.0032	0.0233±0.040
Chrysene	ND	0.4018	ND	0.1339±0.032
Benzo(b) Fluoranthene	ND	0.0337	ND	0.0112±0.010
Benzo(k) Fluoranthene	0.0070	0.4076	0.0013	0.1383±0.102
Benzo(a) pyrene	0.1235	ND	ND	0.0412±0.071
Dibenz(a,h)anthracene	0.3829	ND	ND	0.1276±0.101
Benzo(g,h,i)perylene	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	0.1378	ND	ND	0.0459±0.030
Total	0.8481	0.9792	0.0211	0.6161±0.521

Results obtained for the concentration of PAHs in the abandoned dumpsite disclosed that the degree of occurrence of individual PAHs differed from not identified to 0.4076 mg/Kg. The highest concentration of individual PAHs was recorded in benzo(k)fluoranthene in Station 2. The average value of specific PAHs varied from not identified to 0.1383±0.102 mg/Kg in the dumpsite. The total value of PAHs within the stations of the abandoned dumpsite differed from 0.0211 to 0.9792 mg/Kg. The average values obtained for the total PAHs within the dumpsite was 0.6161±0.521 mg/Kg. The highest value of concentration was detected in Station 2 while the lowest value was observed in station 3. The order of occurrence of total PAHs in the stations of the abandoned dumpsite were 2 > 1 > 3.

The observed values of polycyclic aromatic hydrocarbons in this work were observed to be lower than the required value of 10 mg/Kg for leisure land usage as suggested by the Italian legislation (Guarino et al., 2019). The results obtained in this work for polycyclic aromatic hydrocarbons (PAHs) was lower than the concentration values reportedly obtained in soil samples collected from power generating houses in three universities in Port Harcourt by Edori et al. (2022) which range from 16.53 to 18.18 mg/Kg and also that recorded in an metropolitan and normal forest soils in the Atlantic Jungle, (São Paulo State), Brazil (Bourotte et al., 2009). The total concentrations of PAHs recorded in this work was also lesser than that which was recorded in soils from Lagos, Nigeria (Fatunsin et al., 2019), and that reportedly obtained at contaminated stations in Hisar, India (Bishnoi et al., 2009).

The documented concentrations of PAHs in the considered soils at the various points could be due to the long time that the dumpsite has been abandoned and it has possibly undergone degradation due to the activities of soil plants and animals. Again, other natural factors like rain could have washed away the polycyclic aromatic hydrocarbon components. Also, high temperature occasioned by the sun at certain periods of the years that the dumpsite must have existed might have resulted in the volatility of some of the hydrocarbon components, especially, the lower molecular weight hydrocarbons. This observation is in consonance to that observed by Holoubek et al. (2009) and Edori et al. (2022). The concentrations of PAHs from the studied stations were lower than expected due to the fact that it is different from that which generate emissions from the generators which are associated basically with the nature of the discharged directly to the soil and the land cover as stated by Nam et al. (2008) and Edori et al. (2022).

Environmental contamination by PAHs have diverse fitness problems equally in hominids and the environs, which lies on the gradation of interaction, measure and the trail of exposure (Ekpete et al., 2019). While, the consequences may not be detected on the labor force immediately, but the likelihoods of actuality noticing it late may be a possibility. The effect of PAHs can be encouraged and heightened by the health conditions and the age of the workers that make use of nearby farmland on daily bases. This observation is in agreement with workers that take charge of the daily operation and maintenance of heavy duty engines, as was stated in the article of Adedosu et al. (2015) and Edori and Iyama, (2017) that come in contact with the spent oil on daily bases.

The utmost outstanding and notable effects of PAHs are linked to their carcinogenic and teratogenic causing ability, prompting of dioxin-resemblance activity and frail estrogenic response (Nwineewii & Marcus, 2015). The concentrations of PAHs documented in this piece basically come from the partial combustion of wastes at the dumpsite which is at variance with diesel spilled during top up or refilling of generators, rainfall containing discharged fumes, engine oil and petrol utilized in repairs and overhauling of the generators as observed in the work of Edori et al. (2022) and also that of Korosi et al. (2013) who noted that the presence of PAHs in soils was mainly due to fume waste and dumps within a particular location. The existence of PAHs in the soil could lead to the contamination of ground water by penetrating through the soil contour and also affect the surface water during rainfall whereby it is being drained into water bodies (Al-Delaimy et al., 2014).

Sources identification of polycyclic aromatic hydrocarbons in the abandoned dumpsite

Table 2: Diagnostic ratios of PAHs in in the abandoned dumpsite

Stations	∑LMW PAHs	∑HMW PAHs	LMW/HMW	An/(An + Ph)	Flu /(Flu + Py	BaA/ (BaA + Ch)
1	0.1969	0.6512	0.3024	ND	ND	ND
2	0.0197	0.9595	0.0205	ND	0.1667	0.1476
3	0.0148	0.0063	2.3492	0.7955	ND	ND
Petrogenic			> 1	< 0.1	< 0.4	< 0.2
Pyrogenic			< 1	> 0.1	> 0.5	> 0.35

LMW (low molecular weight), HMW (high molecular weight), An (anthracene), Ph (phenanthrene), Flu (fluoranthene), Pyr (pyrene), BaA (benzo [a] anthracene), Ch (chrysene)

The source indicative relationships of PAHs in soils samples of the abandoned dumpsite as provided in Table 2 revealed that ∑LMW PAHs was in the middle of 0.0148 to 0.1969 mg/Kg, ∑HMW PAHs was stuck around 0.0063 to 0.9595 mg/Kg, LMW/HMW was between 0.0205 to 2.3492, An/(An + Ph) was between not detected to 0.7955, Flu/(Flu + Py) was between not detected to 0.1667, and BaA/(BaA + Ch) was between not detected to 0.1476. Results recorded showed that LMW/HMW ratio displayed together pyrogenic and petrogenic origin of PAHs, An/(An + Ph) revealed pyrogenic source, Flu/(Flu + Py) ratios showed petrogenic origin of PAHs while BaA/(BaA + Ch) ratio recorded was petrogenic.

The application of pinpointing relations in the investigation of PAHs levels in any given environment to display intra-source difference and also the connections that exist among the infecting sources has stood known (Galarneau 2008; Jiao et al., 2017). It is broadly suitable in instituting anthropogenic effect on the level of existence of PAHs in the considered milieu (Yunker et al., 2002; Suman et al., 2016). There is an existence of slight disagreement that is linked with the use of diagnostic ratio in PAHs outline enquiry as a result of certain reservations (Muze et al., 2020). It is a very significant instrument that is worthwhile in PAH discharge source identification in dissimilar environmental media (Tobiszewski & Namiesnik 2012; Onyedikachi et al., 2019). In this work, the level of HMW PAHs were observed to be above that of LMW PAHs in Stations 1 and 2 while Station 3 was the reverse. The ratio of LMW/HMW as was observed to be both pyrogenic and petrogenic. This observation is partly at variance with that which was reported in the investigation of Kadili et al. (2021) which had a ratio of 2.2 which indicated petrogenic or natural source of origin.

Nganje et al. (2014) reported that sources of petrogenic or natural PAHs are geodesic, wooded area fires and volcanic activities and that of pyrogenic or anthropogenic sources of PAHs are oil leaks, oil escapes and ignition of relic fuels. Pyrolytic input sources of PAHs are generated basically from incomplete or partial incineration of carbon-based material at carbonation temperatures (around 400 oC) and could certainly have been occasioned from combustion of fuel, coal and plank. Neff et al. (2003) and Kadili et al. (2021) observed that source and origin of pyrolytic PAHs are principally linked with higher molecular-weight PAHs while that of petrogenic origin are generally related with lower-molecular weight PAHs. The recorded point indicated above is also validated by Mastral and Callen (2000) that lesser molecular weight PAH combinations of 2–3 ring PAHs are perhaps as a result of natural or petrogenic source of origin, while higher molecular weight PAH combinations containing 4–6 rings usually originate from pyrogenic sources. In this investigation PAHs incidence were observed to have come from mutually petrogenic and pyrogenic sources, which indicated the presence of both LMW and HMW PAHs. This observation disagreed with that reported in the findings of Itodo et al. (2019) and Kadili et al. (2021) where LMWPAHs were reported to have originated from petrogenic source.

This work partly agreed and partly disagreed with an earlier report in the investigation carried out by Essumang et al. (2011) where the recorded ratio of (LMWPAHs)/(HMWPAHs) was recorded to be all less than 1 in all cases calculated, which put forward that the PAHs were as a outcome of burning of hydrocarbon produce. Also, De La Torre-Roche et al. (2009) and Ibe et al. (2021) at different times reported that Flu/(Flu+Py) ratio calculated showed both petrogenic and pyrogenic sources in addition to burning of grassland, firewood, and coal which could have also caused elevation to the level of PAHs observed in the work, but in this work it was observed that the Flu/(Flu+Py) ratio calculated was not detected and only showed pyrogenic origin in Station 3. Again, the results reported for the ratio of BaA/(BaA+Ch) in this work indicated source of origin in Station 2 while Stations 1 and 3 were not detected. Furthermore, the ratio of An/(An+Ph) were all lower than one in the work carried out by Tobiszewski & Namiesnik (2012) and Ibe et al. (2021).

Ring size analysis of PAHs in the abandoned dumpsite

Table 3: Ring size analysis of PAHs in the abandoned dumpsite

No. of PAHs ring (mg/Kg)	Stations		
	1	2	3
2-3 rings	0.1969	0.0197	0.0148
4 rings	ND	0.5134	0.0050
5 rings	0.5134	0.4413	0.0013
6 rings	0.1378	ND	ND

Ring analysis from the data above showed that 2-3 membered rings fluctuated from 0.0148 to 0.1969 mg/Kg, 4 membered rings fluctuated from not detected to 0.5134 mg/Kg, 5 membered rings fluctuated from 0.0013 to 0.5134 mg/Kg and 6 membered rings fluctuated from not detected to 0.1378. The average concentrations obtained for the diverse PAHs ring types from the different stations of the studied dumpsite showed a clear predominance of 5-membered ring PAHs followed by 4-membered rings, then 2-3 membered rings and finally 6-membered rings. In general the order of incidence of membered rings was 5 > 4 > 2-3 > 6. The results recorded in this study is at variance with that reported in the work of Edori et al. (2022) from heavy-duty generator stations from three universities in Port Harcourt Rivers State where 2-3 membered rings predominated in all stations employed in the study, trailed by the 4-membered rings, then and there five membered rings and finally six membered rings.

The low levels of 2-3 membered rings or LMW PAHs recorded in this work could be due to the long period the dumpsite has been abandoned and also the regular burning of the dumpsite. The low occurrence of lower ringed PAHs in this work is in consonance with the report given by Edori et al. (2022) in an investigation carried out where heavy-duty generators were used to provide power to the different components of three different universities situated in Port Harcourt. The higher values recorded for higher membered rings or HMW as against those of the LMW PAHs in the abandoned dumpsite could be as a result or possibility of combinations of the LMW PAHs over the long period of abandonment or under high temperature conditions in which the dumpsite has been subjected to due to regular burning. This observation also is in agreement with that recorded in Edori et al. (2022) where heavy-duty generators are being operated. Also, 4-6 membered rings are not easily biodegradable and possesses low volatility, therefore the high incidence of the 4-6 membered rings in the abandoned dumpsite soil that was investigated.

Moreover, LMW PAHs are exceedingly hydrophilic, unstable and soluble, so can be readily detached under very minor variations in environmental conditions (Wu et al., 2019; Edori et al., 2020). Another possible factor that might have made the LMW ringed PAHs to be lesser in concentration when compared to the HMW ringed PAHs may be due to the elevated position of the dumpsite and are therefore easily drained to the lower water logged area. This observation could be the possible reason recorded in the work that indicated higher values of 2-3 membered ring PAHs as against 4-6 membered ring PAHs in Station 3 of the abandoned dumpsite.

CONCLUSION

The levels of PAHs in soil at the three stations of the abandoned dumpsite at Rumuolumeni were assessed. There were generally more PAHs in soil in station 2 than those from station 1 and 3. This suggests more significant anthropogenic input of PAHs in station 2. Consequently, people who are residing in this area might be at risk of adverse health effects of contaminated soil. In accordance, the larger extents of PAHs detected in many built-up soils and the nearness of these soils to human settlement likely predisposes humans to more contact time with these noxious waste by way of breathing, eating or drinking, or skin exchange. Though, familiarity of the long lasting outcome of combinations such as PAHs in metropolitan habitations in Nigeria is insufficient presently, yet it is necessary to define and continuously check concentrations of PAHs in the soils of dumpsites. This is an indispensable phase in decreasing the probable jeopardy to those living close-by. Precise evaluation involves facts or statistics on the quantity and quality of the PAHs in the dumps and explanation on their extensive span destiny in the environs.

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