SANITARY LANDFILL ALONG THE BANKS OF BAGMATI RIVER IN KATHMANDU AND ITS IMPACT ON THE ENVIRONMENT

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Abstract: Present study was carried out from July 2003 to December 2003 in order to evaluate the possible impact of the existing sanitary landfill in the surface water by monitoring the monthly changes in the water quality parameters and seasonal contamination of heavy metals. Soil permeability test was also conducted to check the relationship between surface water pollution and the soil condition. Social survey was carried out to identify the socio-economic impacts associated with landfill operations. The study revealed that surface water pollution and seasonal contamination of heavy metals in the surface water were extremely high within the landfill sites. The landfill activities also had adverse impact on the social life and economy of the local residents.

Key words: Solid waste; Sanitary Landfill; Riverbank; Water quality; Heavy metal.

INTRODUCTION

Solid waste may be defined as all the discarded solid materials from municipal, agricultural, domestic and industrial activities that can neither be transported by water in to streams nor readily escape in to the atmosphere. Owing to rapid industrialisation, the management of solid waste has become increasingly difficult throughout the world. The safe disposal of solid waste is now a growing concern for both developed and developing countries.

The commonly adopted approaches throughout the globe for the disposal of solid waste includes open dumps, sanitary landfill, incineration, deep-well disposal, composting. Among these, sanitary landfill is the most common and is being widely used in developing countries. Since a filled landfill can be reclaimed and used for recreational purposes like parks, golf courses, athletic fields, wildlife areas, its significance is increased. For instance, filled landfill are used as sites for an amphitheatre in Virginia Beach, the Mile High Stadium is constructed over the filled land. About 54 percent of the municipal solid waste in USA, 90 percent in United Kingdom, 80 percent in Canada, 15 percent in Japan and 12 percent in Switzerland is buried in sanitary landfill. (Miller, 2002)

Solid waste management is the most prominent issue in the urban areas of Nepal that requires immediate attention. In this context, solid waste management problems in Kathmandu can not be ignored. Though the country is agrarian and the principle occupation of the people is agriculture, other types of occupation are slowly flourishing in the country owing to rapid industrialization coupled with urbanization. The land use pattern of the urban centres has dramatically changed due to which considerably less land could be allocated for farming. For instance, the built-up areas in Kathmandu Valley have increased from 13 sq km in 1988 to 30 sq km in 1997 (Shrestha and Pradhan, 2000). The major changes has taken place in Kathmandu city area This has significantly altered the composition of the waste. Thus, along with organic wastes, other types of wastes are also rapidly increasing their share. Moreover, these changes have now made the compost making processes of the past in “shagal” quite impracticable. Since, the waste consists of an array of organic and inorganic substance in large volume; waste in Kathmandu is managed through Sanitary Landfill technique.

STATEMENT OF PROBLEM

Waste generation is a natural phenomenon on account of resource utilisation. However, its negligence and mismanagement obviously invites undesirable and suffocating environment. With uncontrolled growth in urban population of Kathmandu, significant increase both in composition and volume of the waste is distinctly noticeable. However, there lies limited resource and area to handle the waste. Thus, solid waste management has become a major environmental concern for all.

Selection of proper Landfill sites has always been a challenge for the authorities. Out of 58 municipalities in the country, only Kathmandu has operating landfill site, which too is not stable. After the official closure of Gokarna Landfill Site in 1999, the landfill activities are carried out along the banks of Bagmati river. The river-bank disposal of waste without taking any precautionary measures is obviously not an environmental friendly technique of waste management. Especially in the core urban city area like Teku, its effects can further magnify,

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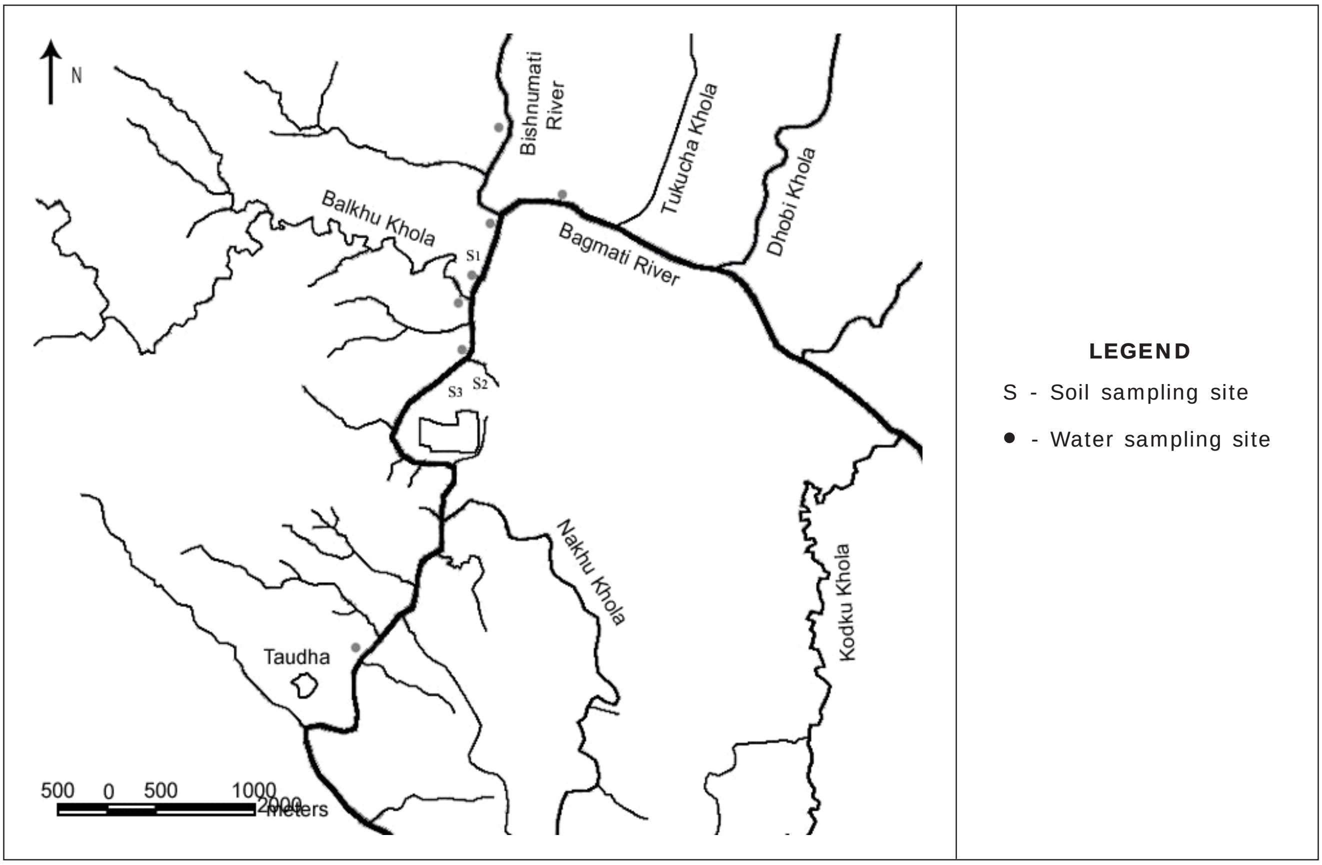

Fig. 1: Drainage map of study area (Kathmandu Valley)

as the human settlement is quite high. Thus, such activities are very likely to invite severe consequences on the health and environment in future and have to be seriously addressed.

OBJECTIVES

The research was conducted with the following objectives:

- To determine the state of river water quality before and after its entry in to the Landfill site.
- To identify the seasonal contamination of selected heavy metals in the surface water.
- To study selected engineering properties of the basal materials of the duged-out trenches.
- To survey impacts on health and social life condition of the residents.

MATERIALS AND METHODS

During the study, for the analysis of surface water quality and heavy metal contamination, seven sites were considered: three sites upstream the landfill (ULS), three sites within the landfill (LFS) and one site downstream the landfill (DLS) (Fig. 1). The undisturbed soil samples were collected from three different sites within the landfill area from duged-out trenches and analysed following the methods described by Lambe (1951) and ASTM standard (1986). Social survey of thirty households lying within and close to landfill was carried out using structured questionnaire by direct interview.

The water quality tests were conducted according to the standard methods prescribed by APHA (1998) and Trivedy and Goel (1984). Parameters and methods used for the present study are listed in Table 1.

Table 1: Parameters and methods used for the study

Parameters mg/l	**Method**	**Parameters (mg/l)**	**Method**
Temperature	Direct measurement	Cobalt (mg/l)	PAN method
pH	pH meter	Copper (mg/l)	Bicinchoniate
DO (mg/l)	Modified winkler's	Nickel (mg/l)	PAN method
Chloride (mg/l)	Argentometric	Total Iron (mg/l)	Ferrover
Nitrate (mg/l)	Phenol disulfonic acid	BOD (mg/l)	5-days titrimetric
Orthophosphate (mg/l)	Ammonium molybdate	COD (mg/l)	Open reflux`
Grain size analysis	ASTM, 1986 method.	Plastic and Liquid limit	Lambe, 1951 method
Soil permeability	Variable head method		

RESULTS

Water Quality and Heavy metals

During the present study, prior to the entrance in to the landfill site, the comparative analysis of the surface water samples from three major streams namely Bagmati, Bishnumati and Balkhu in the upstream indicated that the sampling site within Bishnumati river (Kalimati Bridge) was the most polluted one. The sampling site within Bagmati river (Pachalighat) followed it. While sampling site within Balkhu river (Kumari Club) was observed to be the least polluted site.

After the entrance in to the landfill site, the load of pollution in the surface water and heavy metal contamination increased tremendously crossing permissible limits in most of the parameters (Fig. 2-6). Furthermore, the load of pollution has actually declined downstream.

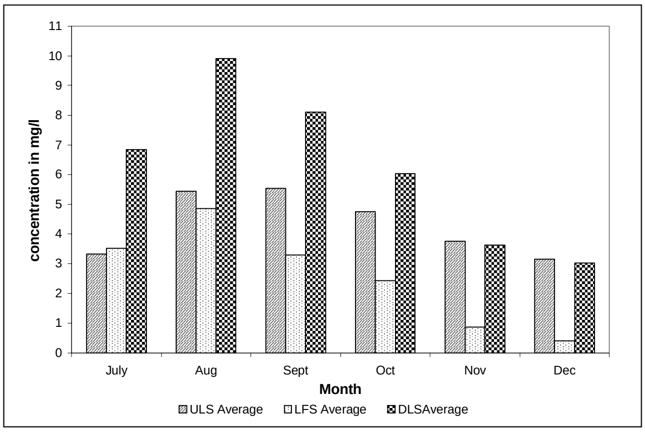

Fig 2: Monthly variations in dissolved oxygen of water at different sites

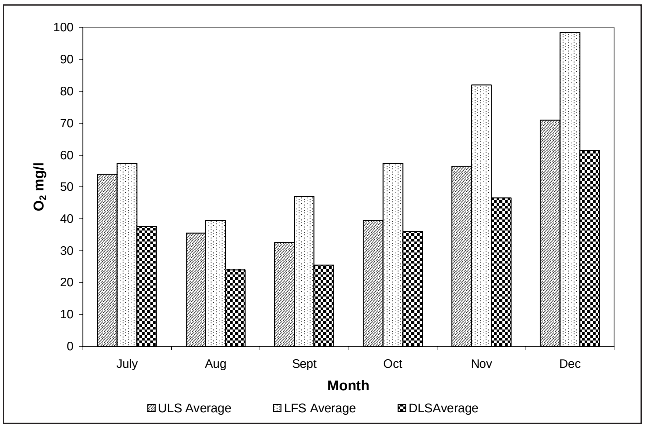

Fig 3: Monthly variations in BOD load of water at different sites

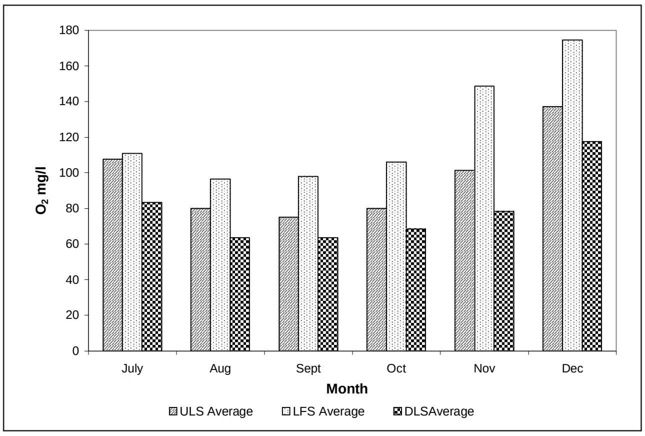

Fig 4: Monthly variations in COD load of water at different sites

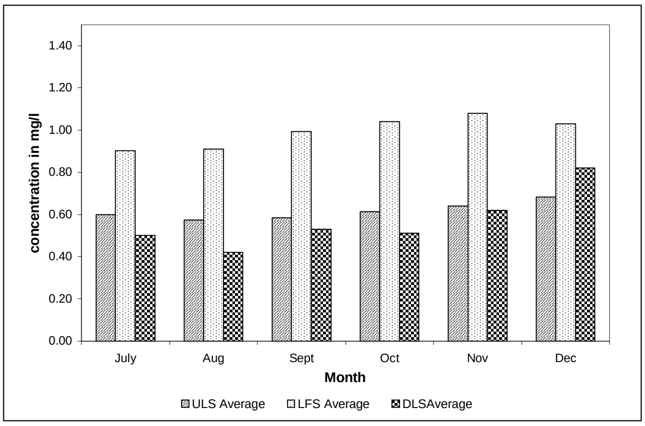

Fig 5: Monthly variations in orthophosphate concentration of water at different sites

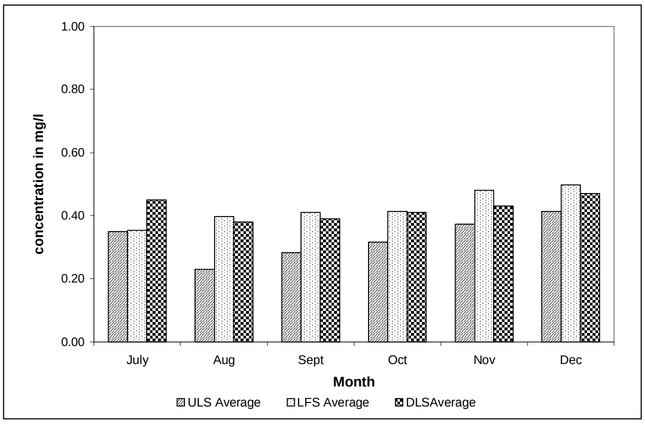

Fig 6: Monthly variations in nitrate concentration of water at different sites

(a) DO, BOD and COD

Marked decreased in Dissolved Oxygen (DO) concentration was distinctly noticed within the landfill sites compared to the other sites throughout the sampling period. In contrast to this Biological Oxygen Demand (BOD) load of the landfill sites had increased in the same site. This indicates the high load of organic pollutants flourishing the growth of decomposer organism that deplete DO of the surface water and thereby increase BOD load (Figs. 2 and 3).

Similarly like BOD load, the Chemical Oxygen Demand (COD) load within the landfill sites was extremely high. Since landfill site lacked the facility of proper segregation of the waste and all the inorganic and organic compounds were dumped in the same place, it was obvious that COD load was high here (Fig 4).

(b) Orthophosphate and Nitrate

Conspicuous increase in the orthophosphate concentration and steady increase in nitrate concentration was noticed in the surface water within the landfill sites during the study (Figs. 5 and 6). The increase in phosphate and nitrate could be due to the cumulative effect of the addition of domestic sewer drains, human interference like washing, bathing in the upstream and downstream the landfill sites, seepage of concentrated leachate, addition of wastes from cremation places and agricultural runoff.

(c) Heavy Metals

The seasonal analysis of heavy metals in the surface water from upstream, landfill sites and downstream, indicated that heavy metal concentrations were higher within the landfill sites compared to other sites. Nickel and Cobalt were detected to have higher concentration within landfill sites during monsoon season. In contrast to this, Copper showed less concentration during monsoon season while iron indicated steady level (Figs. 7, 8, 9 and 10).

Soil analysis

The result obtained from analysis of the soil samples revealed that it was fine grained silty sand, non-plastic and non-liquid. It showed an average value of 0.023 X 10^{-6} m/s for coefficient of permeability.

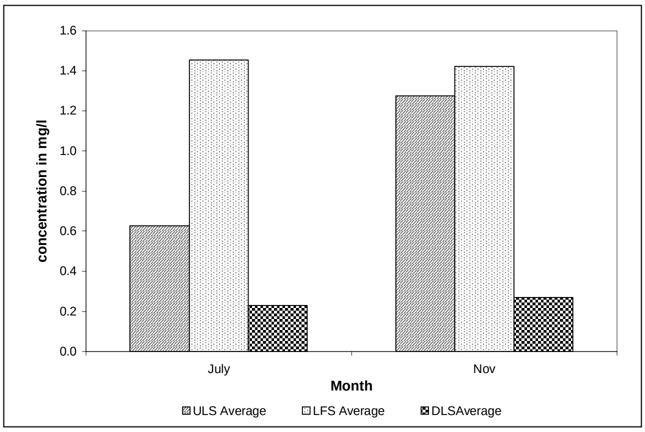

Fig 7: Total iron concentrations in water at various sites in wet and dry months

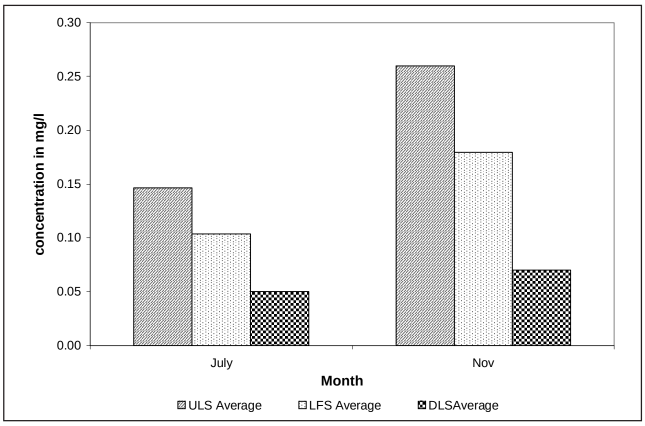

Fig 8: Copper concentrations in water at various sites

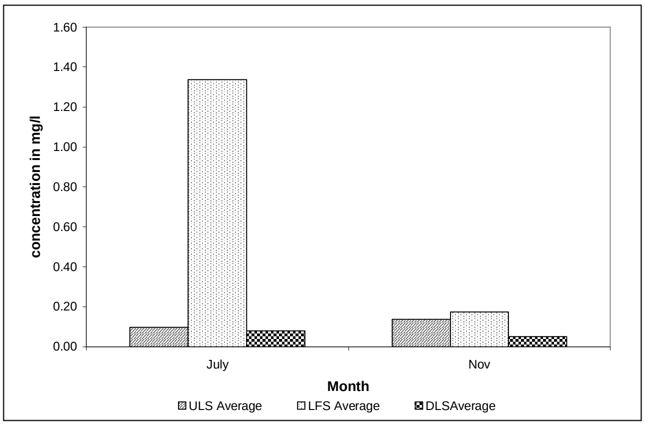

Fig 9: Nickel concentrations in water at various sites in wet and dry months

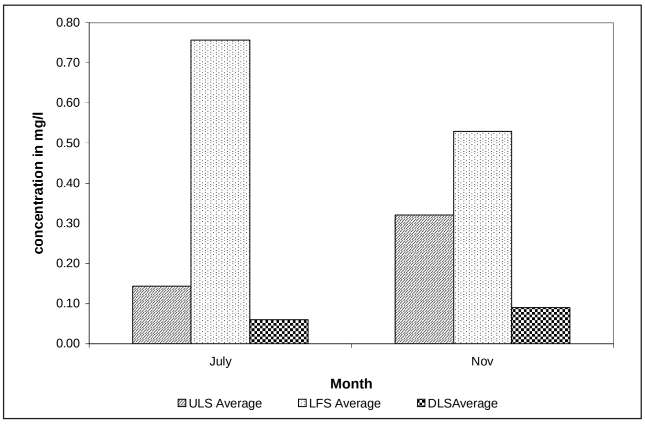

Fig 10: Cobalt concentrations in water at various sites

Social Impacts

Among the 30 households surveyed, 66.67 percent responded to the fact that the peripheral area of the landfill site has deteriorated due to the existing landfill site. Ninety seven percent of them claimed that river water deteriorated due to increased pollution load. The locals were also found hesitant to use ground water. Forty three percent respondents were reluctant to use ground water and relied completely on tap water.

More than half of the respondent (53.33 percent) claimed that their social life and economic activities (agriculture, business, and rental system) was adversely affected by nearby landfill site. For 73.33 percent of the locals, the scavenging animals like dogs, pigs, eagle and crow had been a nuisance. Moreover, the entire respondents (100 percent) agreed to the fact that enormous populations of mosquitoes, houseflies etc had made the environment simply intolerable. Commonly observed health impacts included nausea and loss of appetite, diarrhoea and intestinal disorders, headache, skin diseases, etc.

DISCUSSION

Sanitary landfill always has negative impact on the existing environment. The landfill affects the existing environment in different ways. Generally, it is the surface water that gets immediately contaminated through the discharge of leachate. Depending upon the soil characteristics and precautions taken during landfill operation, the extent of ground water pollution could be foresighted.

Devkota et al. (2004) studied the water quality around Gokarna Landfill Site on the surface, shallow wells and leachate based on field observation and laboratory analysis. They noticed that the load of pollution was high in the surface water nearby the landfill site compared to the sampling sites distant from landfill sites. Increase in nitrate, phosphate, iron, chloride was apparent from their study.

Similarly, Shrestha (1998) also concluded conspicuous increase in pollution parameters in the surface water and stone tap nearby the landfill site at Gokarna. Sharma et al. (1995) observed that the surface water of Bishnumati river, which was temporarily used, as landfill site, acquired high pollution load at sampling sites where leachate was released while steadily declined downstream. Incredible increase in alkalinity, chloride, hardness, COD, iron etc were seen during the study.

In the present study, there was marked increase in BOD, COD, orthophosphate, nitrate, total hardness, total dissolved solids, total suspended solids, total alkalinity within the landfill sites compared to upstream and downstream. Similarly, heavy metals like total iron, nickel and cobalt concentrations were also detected to be extremely high within landfill site. However, marked decrease in DO concentration within the landfill site was observed throughout the study. Hence, it is very obvious that the three locations within the landfill area were most polluted as compared to other sampling sites. The obvious reason for such deterioration in the water quality is because of the seepage of concentrated leachate from the buried wastes along the banks. This was further proved by the soil test results. The soil analysis within the landfill sites confirmed the fact that the basal material of the trench that was used to bury the waste was composed of mostly silt and fine sand and very little clay. The silt dominated in most sampling sites. Moreover, the permeability tests indicated that the coefficient of permeability in all sampling sites considered were in the order of fine sand and silt but were far above the order for clay. Besides, the liquid and plastic limit test also confirmed the same fact that the clay content was poor in all soil samples. While sampling it was also noticed that the river water intrusion in the trenches from the adjacent water body was significant. Hence, the pollutants can easily make its way in to the river water.

The geological map of Kathmandu Valley reveals that the present landfill site lies within Kalimati formation and is thus, an appropriate area for sanitary landfill purpose. However, from the study, it was found that the base of duged trenches contained less clay and more silt. Thus, it is clear that the depth of the trench duged out was simply not sufficient. Due to the domination of silt and fine sand the leachates from the waste dumps have already made their way in to the river water and thus, the surface water has already been polluted. If such condition prevails, then the shallow water aquifers are the most critical sites that could be contaminated by leachate.

The social life of the people has been adversely affected due to the current landfill operation. People are finding hard to reside nearby the landfill site as the obnoxious smell and exponential increase in the population of flies has made the environment not worth living. Since, the insects serve as vectors for carrying the germs of various diseases, people felt insecure in their own backyards. This condition has further worsened due to never ending noise and air pollution created by land filling activities. Besides, disturbances caused by the flock of scavenger birds, dogs, pigs etc in the social life have become an irritating routine. People claimed that business is also adversely affected due to the present landfill activities as clients avoid carrying out business dealings in such repulsive environment.

CONCLUSION

From the study, it can be concluded that the surface water pollution in Bagmati river along the landfill site is extremely high. The soil test had confirmed that the marked increase in pollution in the surface water is primarily due to uncontrolled and unregulated seepage of the leachate from the adjacent waste dumps.

Although there were no direct visible serious health impacts due to the landfill activities, the obnoxious odour, air and water pollution along with increased flies and scavenging animals had made the environment suffocating for the residents.

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