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Impact of Okhla, Bhalswa and Ghazipur Municipal Waste Dumpsites (Landfill) on Groundwater Quality In Delhi

SONAM ANGMO* and SHACHI SHAH

School of Interdisciplinary and Transdisciplinary Studies, IGNOU, New Delhi, India.

Abstract

Rapid urbanization, increasing prosperity, economic development coupled with changing lifestyle has produced a tremendous generation of waste in huge quantity. The dumping of this huge quantity of partially segregated waste has become a public health and environmental concern. According to an estimate, more than 9500 tons per day (TPD) of MSW (Municipal solid waste) is generated in Delhi and about 60% of waste is transported to these three-active landfills in order of maximum in Bhalswa followed by Ghazipur and Okhla landfill sites which are non-scientific landfill and less than 40% were transported to composting plant and waste to energy plant. These waste dump sites have finished their commissioned date and crossed the permissible height and come under matured landfill (old). Dumping of unsegregated waste in these landfills contribute long-term threat to groundwater as various parameter such as inorganic, organic and heavy metal liberate from leachate of unsegregated solid waste and concentration varies with season. Soil contamination, air pollution and various other environmental, health and social impacts in the vicinity of these landfills are found to be connected with uncontrolled dumping of waste. The study reported that,till date in Delhi, there is no single landfill which is controlled and provides with baseliner or proper cover. All three active landfill still received solid waste beyond their capacity without any attention to waste segregation. Impact of landfill leachate on groundwater revealed by presences of high concentration of various parameters like Chloride, Nitrate, Sulphate, Ammonium, Phenol, Iron, Zinc and Chemical oxygen demand in assessed which showed that quality of groundwater is significantly affected by the percolation of landfill leachate. The main problem of the landfill is the generation of toxic leachate and gases which finally end their life in groundwater and environment and ultimately reach to human and damage aquatic life present in water. On the other hand emission of greenhouse gases lead to the risk of fire and also cause global warming. Presently NGT had warned officer of these three landfills of Delhi to remediate landfill. There is an urgent need of leachate collection system and treatment facilities and gastrapping technologies at this landfill for energy generation and to protect the contamination of groundwater.

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CONTACT Sonam Angmo sonamangmo111@rediffmail.com School of Interdisciplinary and Transdisciplinary Studies, IGNOU, New Delhi, India.

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Introduction

Solid waste dumping in an open area without plan lead to a major problem for municipalities in India and worldwide. As mentioned in Solid Waste Management Rule 2016, this rule is also applicable to waste generate from Religious place, Port, Airport includingMunicipalities.[1] Sustainable way of waste management are reduce, reuse, recycle, recover and last option is landfilling. Landfills though provide a quick and easy solution but pose a grave threat to the environment, economy and society through emission and liberation of landfill gas, leachate and associated pollutants which adversely affect climate, ecosystem, water resources, land and human health.[2] It has been found that (MSW) Municipal solid waste dumpsites are responsible for all kind of environmental pollutions.[3] In developing countries, most of the cities dispose their waste in a dumpsite in an unplanned manner and also bigger cities like Delhi where availability of space for waste disposal is very limited.[4] Uncontrolled municipal solid waste dumping in landfill results in negative health impacts and also emission of toxic gas, the liberation of concentrated leachate which gives harmful effect on the ecosystem than polluting surrounding soil, subsoil, inland water, and groundwater.[4] These negative impacts can be reduced by the use of eco-friendly technologies and suitable solid waste management technologies.[6]

The major contributor of the mountain like the structure of uncontrolled dumpsites is non-biodegradable plastic waste and after mixing with other construction and demolition waste give a structure of the mountain. Most of the landfill received non-segregated waste from residential area, commercial and industries area without primary or secondary segregation. During rainy season water percolated in waste of uncontrolled landfill has generated in form of leachate can give harmful or serious threat to human health and water bodies.[7] As rainwater penetrates through the waste layers; within the solid waste, all physical, chemical, biochemical and microbiological reaction takes place due to interstitial water content of the waste.[8]

The contamination potential of the landfill leachate can be calculated by an Index proposed by Kumar and Alappat known (LPI) leachate pollution index. It is also applicable in the ordering of landfill site from higher to lower, resource sharing in a particular way for landfill remediation, scientific research and information based on leachate contamination which was prepared by using Rand Corporation Delphi Technique.[9]

The aim of the paper is to study the status of Okhla, Bhalswaand Ghazipur Municipal Waste Dumpsites (landfill) with the objective to assess the impact of these municipal waste dumpsites (landfill)on groundwater quality in Delhi and suggest recommendations for sustainable solid waste management.

Status of Municipal Solid Waste In Delhi

Delhi is most urbanized and densely populated metropolitan city which generate about 9000 (MT) metric tonnes of solid waste every day which may go up to 17000-25000tons per day by the year 2021.[10] According to (CPHEEO 2000) per capita municipal solid waste generation of Delhi is 700g/day which is five times the national average.[11] The average domestic hazardous waste generated in Delhi was 0.03±0.01kg per day per home and source of these waste were Batteries, paint, CFL bulb, discarded syringes, broken mercury thermometer, discarded medicines etc.[12] When these wastes are interacting with other solid waste and finally dispose of in landfill lead to a high potential risk to groundwater and environment because of the presence of heavy metal in domestic hazardous waste. Improper collection and transportation of waste are the reason for the accumulation of waste at every corner. The efficiency of collection of waste in big cities in India range between 70% and 90%, whereas in small efficiency is below 50%.[11]

National Capital Region of Delhi cover five civic bodies which are North Delhi municipal corporation (NDMC), South Delhi municipal corporation(SDMC), East Delhi municipal corporation (EDMC), New Delhi Municipal Council(NDMC) and last, is Delhi Cantonment Board(DCB). National capital of India (Delhi) consists of 11 districts and each district have no. of wards, colonies and villages. National green tribunal(NGT) of India ordered three municipal corporations of Delhi to taken approaches to notified specific wards into model wards and to focus on segregation of waste at the source of generation viz. household, commercial establishment etc. According to Solid Waste Management Rule 2016 which include various steps for collection to disposal of waste

through various scientific and modern technologies. NGT has also requested these municipalities for the establishment of decentralized waste processing and material recovery facilities.[13] East municipal corporation of Delhi reported execution of "NIMBY" (Not in my back yard) are a behavioural hindrance for the execution of waste management plan in Delhi resulting in a large amount of waste in all the open dumpsites.[14]

Status of Municipal Waste Dumpsites (Landfill) at Delhi

Open waste dumping or landfilling is still practised in India. Metropolitan cities like Delhi, Mumbai, Kolkata and Chennai etc. have inadequate availability of land for waste disposal and present active used landfill sites are running beyond their intake capacity.[15] According to Census 2011, Delhi is having a geographical area of 1483 km2 and the population is 11,034,555.[16] The Delhi population is increasing daily because of migration of peoples for job, education and business etc, need of land for construction and habitation for peoples is also increasing simultaneously, which resulting in a shortage of land for landfill. Most easy and inexpensive waste disposal method is landfill but overall life cycle assessment highlights the concealed cost associated with it.[2] In Delhi, there are three active uncontrolled and unlined Municipal solid waste landfill/Dumpsites sites at East, North and South Delhi i.e., Bhalswa, Ghazipur and Okhla (Table 1).

Table 1: Three uncontrolled/active landfill site in Delhi

S.No	Name	Location	Area (hectares)	Starting year	MSW received T/day	End of landfill life
1	Bhalswa	North Delhi	26.22	1993	3200	2005
2	Gazipur	East Delhi	29.62	1984	2100	2008
3	Okhla	South Delhi	22.89	1994	1200	2005

Source-37

Fig.1: Landfills in Delhi. Source:Google Map

The Bhalswa, Ghazipur and Okhla landfill site receives waste mostly from the residence of, North, East and South Delhi along with waste from the vegetable market, poultry and industries.[17] Above mentioned active landfill site has a lack of leachate collection system and greenhouse gases (methane and carbon dioxide) trapping facilities. Landfills have been categories as young, intermediate and stabilized depend on no. of year used.[18] These three-landfill site come under the old (Stabilized) landfill site category. These open dumps are more than 25 years old but still waste being disposed of without any primary or secondary segregation. Table 2, show present infrastructure and facilities available at three landfills of Delhi.

Table 2: Present infrastructure and facilities available at three landfill of Delhi

Landfill Site	Area (acres)	DOC (Date of commissioned)	Zone covered in waste collection	Border fence	workers	Equipment in used	Gas Venting	LCS (Leachate collection system)
Bhalaswa	40	finished	Rohini, Civil Line, Karol Bagh, Narela, Najafgarh	Not completely	130	Six Bulldozers, Two Hydraulic Excavators, One Backhoe Loader	No	No
Ghazipur	70	finished	North and South Shahdara, City, NDMC, and SadarPaharganj.	Not completely	80	Five Bulldozer, Two Hydraulic Excavators, One Bachoe Loader	No	No
Okhla	32	finished	South, Central, Najafgarh and Delhi Cantonment Board ((DCB)	Not completely	80	Two Bulldozers, Two Hydraulic Excavators One Backhoe Loader	Yes	No

Source: (19, 20, 21, 22, 23, 24)

These landfills are unlined base and also without proper cover. Because of this avian diversity are hovering over landfill during day time. Leachate generated during pre-monsoon, monsoon and post-monsoon is flowing in a different direction and finally drain into the canal outside the landfill. Also, these three active landfills lack chamber facilities to capture various toxic gases and which may lead to fire break risk at a landfill and also health problem to people living in the vicinity and landfill worker of respective landfill. Facilities like a waste to energy treatment plant are established in Delhi but the emission of toxic carcinogenic gas from chimney cause various health issues to a nearby resident of landfill. Now we will discuss the three landfill site in detail.

Fig. 2: Okhla Landfill Source: Sonam

Okhla Landfill

This landfill site is located at Okhla Phase-I at latitude and longitude of 28º30′42.05″N 77º17'4.47"E which is close to National Highway-2 from front main gate site of the landfill and also ESIC hospital is just adjacent to the landfill on South-East end of the city, established in 1994 and decommissioned in 2018. The area of the landfill is 56 acres. The site serves for the dumping of solid waste generated from South Delhi and Central Delhi. The SLF receive around 2000 MT of Solid Waste daily told by Consultant Okhla landfill. There is no arrangement for leachate collection and treatment at this site. Leachate is being disposed into the existing sewer through open drains. The solid waste received at the site is levelled, restructuring and compacted with the help of hydraulic bulldozers.[25]

Out of total waste from South Delhi, 46% of non-segregated waste are received by Timarpur Okhla waste treatment plant run by Jindal Ecopolis company near SukdevVihar, Jasola where these wastes are converted into energy i.e. electricity. Various type of toxic gases which are released from waste to energy plant negatively affect the health of people residing in the vicinity of this plant. On the other hand, 3% biodegradable waste is converted into compost by IL&FS(Infrastructure Lease and Finance services)which is just opposite to the waste to energy plant of Jindal Ecopolis private Limited and finally, 51% of solid waste is directly dumped in landfill.[26] As per consultant (SLF) sanitary landfill, South Delhi Municipal Corporation (SDMC) has planned new scientific landfill will be constructed near Tekhand village near current active Okhla landfill site and also set up waste to energy plant extension of present waste to energy plant.

Bhalswa Landfill

The Bhalswa landfill is located between28°42'30" to 28°45' latitudes and 77°7'30" to 77°11'54" longitudes in north-west Delhi in most urbanized and area about 5 hectares.[27] This uncontrolled and unlined base landfill used for dumping of the municipals solid wastes and industrial wastes. One side of this landfill is aligned by the River Yamuna.[28] Municipal solid waste is disposed of in this landfill which comes under the jurisdiction of North Delhi Municipal Corporation. It received unsegregated waste from an area such as Rohini, Narela, Karol Civil Lines, and West Delhi. The area like Bhalswa, Shalimar Bagh, Azadpur, Jahangirpuri, Siraspur, Jahangirpura, Nathpura, Model Town, Pitampura is residential areas located within the buffer zone of 5km.[2]

Ghazipur Landfill

The Ghazipur landfill is an uncontrolled and active landfill of Delhi and its management comes under the jurisdiction of East Delhi municipal corporation (EDMC) it covered an area of approximately 3 x 105 m2 and close to National Highway 24.[29] On an average, 2200 MT/day of waste include domestic waste to construction and demolition are dump in this landfill the waste compaction height of landfill waste varies from 12 m to 20 m. It is located at the close to Hindon Canal.[28] Ghazipur landfill also received unsegregated waste transported through municipal vehicles from east Delhi. An only small portion of waste is segregated by rag picker like glass material, plastic and metals and they sell this to the recycling units for their livelihood source of income.30 Recently Delhi government Chief Minister launched new waste to energy plant at Ghazipur poultry market for the treatment of 15 tonnes biodegradable waste of East Delhi market area per day through biogasification and will produce 1,500 unit of power.[31] These waste to energy may reduce some burden to Ghazipur landfill and will boost the economy of the nation.

Fig. 3: Okhla Landfill Leachate(backside view) Source: Sonam

Leachate Characterization of Active Solid Waste Dumpsites of Delhi

Characterization of municipal solid waste landfill leachate generally represented by the parameters like COD (Chemical oxygen demand), BOD (Biological oxygen demand), TOC (Total organic carbon), pH, Suspended solid, Ammonium nitrogen, total Kjeldahl, No. of bacteria, Turbidity and heavy metal value.[32] The composition, the quantity and derivation of possible pollutants of leachate from the solid waste depends upon several agents, such as the form of waste, seasonal variation, precipitation level, degree of compaction of waste, temperature, pH, size, hydrology situation in the surrounding of the landfill (dumpsite) site, engineering and working factor of the landfill, biochemical reaction.[33,34,35]

The production of leachate varies and depend on four phases: The first phase is short and takes place in the presence of oxygen which is represented by the aerobic break down of organic matter or biodegradable item present in solid waste when the oxygen is depleted, then second phase start and degradation take place in the (anaerobic) absence of oxygen. The acidogenic and methanogenic are two phases of anaerobic degradation which help in the generation of biodegradable leachate and stabilized leachate.[36]

According to (Afser *et al*., 2015)out of three active landfill leachate, Bhalswa landfill leachate have the highest concentration of Total dissolved solid (9636 Mg/l), Total suspended solid (10070 Mg/l) and Electrical conductivity (14632 mhos/cm). Biological oxygen demand and chemical oxygen demand of the Bhalswa landfill site is also quite high and its range between 3300 Mg/l to 5840 Mg/l followed by Ghazipur and Okhla landfill. The concentration of heavy metals in leachate samples of Bhalswa landfill quite high after that Okhla followed by Ghazipur.Other Parameters like Ammonical nitrogen, magnesium, potassium, phosphate were found in higher concentration in Okhla landfill in comparison to Ghazipur andBhalswa landfill site.[37]

Leachate Pollution Potential (Lpi) of Municipal Waste Dumpsites (Landfill) In Delhi

Leachate contains a various parameter of pollutants such as a heavy metal like Cu, Cr, Cd, Zn, Fe, Pb Ni and Fe. Chemical Organic compound such as Polyaromatic hydrocarbon, Benzene etc. other physiochemical parameters is suspended solid, soluble inorganic salt, total nitrogen, ammonia, nitrate also in leachates. Leachate is also found to be contaminated with microorganisms including Coliform(total coliform and faecal coliform) Mesophilic and Psychrophilic bacteria, fungi, aerobic bacteria etc. These pathogenic organisms finally migrate into water and soil environment which cause the sanitary and epidemiological hazards.[38]

Leachate pollution index (LPI) is an index which is used in comparison among various landfill on the basis of contamination potential from high to low in a given geographical and was systematize using Rand Corporation Delphi Technique.[39] The (LPI) Leachate Pollution Index can also be employed in to compare different landfills around the world on the basis of calculating LPI value. A high value of LPI indicates that landfill is more contamination and low LPI value indicate low contamination in a given landfill. A single value of LPI indicates the impurity or toxicity potential of landfill. Leachate pollution index of Okhla dumpsite (landfill) Delhi was studied by (Purwar 2018) showed the presence of chlorides, BOD and COD parameters in leachate samples and LPI value of landfill were 62.32 in summer season and 44.14 in winter season significantly.[25] Theanalyzedcollected leachate samples from Bhalswa landfill was found to having a high concentration of chlorides,(BOD) Biological Oxygen Demand and (COD) ChemicalOxygenDemand.[27] Leachate Pollution Index of three active landfills of Delhi and assess that landfill leachate sample of Bhalswahave high Leachate Pollution Index value followed by Ghazipur and Okhla landfill. However, the LPI values at all the three landfill sites lie was almost of the same range. On the physicochemical composition basis, it has been observed that maximum waste disposed of in Bhalswa landfill are mostly the (MSW) Municipal Solid Waste.[40]

Impact of Municipal Waste Dumpsites (Landfill) on Groundwater Quality In Delhi

Gases emission such as Methane, carbon dioxide etc. and water pollution due to leachate are the main environmental issue directly linked with landfill and also groundwater and surface water contamination).[41] As landfill leachate contaminate soil and reached into surface water, then groundwater and make water non-potable, unfit for domestic use. Also, leachates enter the food web/chain over long-term exposure. Studies on bacteria,[42] molluscs43 , fishes,[44] mice,[45] plants[46] human[47] have shown bioaccumulation.

At Bhalswa landfill the impact of leachate collected for analysis of various parameter have found highest concentration of EC (Electrical conductivity)TDS (Total Dissolved Solids) and TSS (Total Suspended Solid) i.e 14892 mho/cm, 9890 Mg/l, and 12580 Mg/l respectively and this result showed the impact on groundwater and biodiversity because of high concentration leachate generated from solid waste.[48] Methane emission from three landfill site of Delhi i.e. Bhalswa, Ghazipur and Okhla are 91.23Gg/yr,3845.20Gg/yr and 77.42Gg/yr which is rising upward rapidly due to overgrowth in population and consumption of resource lead to a generation of

waste so, there is an urgent need of mitigation step to controlling greenhouse gases emission landfill.[49]

Surface and groundwater contamination occurs mostly because of migration of leachate from landfill where there are no facilities of leachate collection system which later reach to water aquifers.[50] According to IIT Delhi, 2019 that Mean annual leachate percolation from East Delhi landfill site i.e Ghazipurbase has been approximate as 24.36 million litres by using a Hydrologic Evaluation of Landfill Performance model. In the apex monsoon season, i.e July month propagation of surface runoff even come up to a level of 1.39 million litres per day.[51] Impact of landfill leachate on groundwater revealed by presences of high concentration of various parameters like Chloride, Nitrate, sulphate, ammonium, phenol, iron zinc and chemical oxygen demand in assessed which showed that quality of groundwater is significantly affected by the percolation of landfill leachate.[4,52] Leachate also contains heavy metal which can contaminate the surface water.[53] Heavy metal concentration in leachate is found beyond the drinking water standard and it reaches to the human body. Toxic heavy metal can destroy life found in water bodies by buildup, example is selenium, mercury, iron etc. It can also destroy aquatic life and animal population feeding is a prime example.[54]

The concentrations of heavy metal were in the order of Fe(6.7)> Ni(3)>Cr(1.5)> Pb(1.2)> Zn(1.1) >Mg in mg/l in a sample of groundwater collected in the vicinity of Okhla landfill.[54] By natural processes like oxidation-reduction reaction and ion exchange processes (Fe) iron can be moved into the groundwater and other physical, chemical and biochemical reactions in the water body aquifer system. Various domestic hazardous waste like batteries, paint, pipes, photographic film is disposed of in a landfill without segregation which is a source of Lead (Pb) and can be released from solid waste in leachate. A high concentration of chromium salts, could corrode the intestinal tract and also rapidly move out from the body .56The presence of a high concentration of (BOD) Biological Oxygen Demand,(COD) Chemical OxygenDemandandhigh value of (LPI) Leachate Pollution Index in the leachate of Okhlalandfillhas notable impact on the quality of groundwater in the vicinity of dumpsite (landfill).[25] The groundwater samples collected for the calculation of water quality index (WQI) in the vicinity of landfill showed high contamination of various pollutant. The people settled near to these three uncontrolled landfills has a high risk of health and water resource problem, especially during post-monsoon and monsoon season.[12]

Groundwater pollution in the surrounding place (vicinity) of Bhalswadumpsite (landfill) site in Delhi, becomes a serious issue because of heavy metal in leaching from the solid waste.[27] At Ghazipur landfill, source of these heavy metal because of dumping of domestic hazardous waste along with other categories waste in dumpsites like batteries, paint, pipes, CFL, and burning vehicle tyres waste dumping at the landfill site. Source of Lead (Pb) can be paints, batteries and pipes which proved the leachate contains heavy metal with much higher than the set standard.[4,57] The concentration of Copper (Cu) was found high in leachate and the source may be disposed of sharps, bottle, lids, paints, beauty product and some medicinal products.[58] Nickel (Ni) and chromium (Cr) were also found in the leachate. Manmade source of (Fe) iron and other sources of it in groundwater is from the steel industry which disposes of their industrial waste in the landfill without pretreatment.[59] A soil sample collected from three active landfills of Delhi has a metal concentration higher than standard set for effluent and also many Polycyclic Aromatic Hydrocarbons were also analysed in the landfill, soil by Selective Ion Monitoring mode in order to know the contamination potential. The concentration of polycyclic aromatic hydrocarbons was observed maximum in Ghazipur followed by Okhla and Bhalswa landfill sites. On the basis of the soil of landfill studies, it has been found that soil of east Delhi landfill (Ghazipur) has high genotoxicity and cytotoxicity than other South and North landfill Okhla and Bhalswa landfill sites of Delhi.[60]

These landfills adversely affect sanitary workers health as waste from different corner of an urban area (Delhi) is transported to these three active land sites fill and is managed by them. At each landfill there is worker involved in the management of waste disposed of in the landfill, some of them work as a bulldozer driver in the restructuring of the landfill and many of them work in remediation without a supply

of proper mask, glove and shoes. They work at landfill without proper personal protection facilities. Ragpicker also comes inside the landfill for collection of plastic, Metal, Electronic items, and rappers which may be converted into value-added product and generate some income for their livelihood. Because of these most worker suffer from various disease problems like Respiratory, dermatitis, eye redness and vital organ defect. Some possible impacts of gases emission from landfill and flashing include fire explosion, unconsciousness or numbness, human health problem, foul smell or annoyance odour, harm to plant and animal, turbulence noise pollution, and heat.[61] People working in landfill site as a worker had a seriously higher chance of Respiratory symptom, and they suffered more often from stomach pain or diarrhoea, infection such as fungal and rashes of the skin, burning sensation in the extremities, inflammation of airway, numbness, partial loss of memory, and depression and higher prevalence of health problem in most of the waste handler.[62]

Conclusion

Leachate Pollution Index (LPI) is considered as a potential technique to identify the hazardous potential of the landfill sites leachate and to further prevent leachate migration and groundwater contamination and treatment. Leachate pollution index of these landfills always found beyond the set standard value of 7 and has been studied by various researcher Bhalswa>Ghazipur>Okhla landfill. To deal with the exponentially growing municipal solid waste, environmentally benign practices including infrastructure for waste minimization, collection of segregated waste, transportation, processing, treatment and least prefer landfilling and sustainable solid waste management technologies are need of the hour.

Recommendations for Sustainable Solid Waste Management

The recommendation for sustainable solid waste management and mitigating the impacts of Bhalswa, Ghazipur and Okhla municipal waste dumpsites (landfill) of Delhi on the environment are as follows:

- Rapid population growth in Delhi leads in the rise of a generation of MSW. As a result, management of waste become herculean work and waste littered everywhere to become a common site. NGO based organization in Delhi can assist the local govt in solving waste management crisis.
- Segregation is the first important step of waste management so training should provide to ragpicker, a sanitary worker for segregation of waste into biodegradable and non-biodegradable waste.
- Gases responsible for Global warming (methane and carbon dioxide, etc.) and fire break in landfill can be reduced by primary segregation of municipal solid waste at source or point of generation. This organic waste has high potential in conversion into manure by composting or vermicomposting and energy generation through biomethanation at a decentralized level.
- Most of the high calorific value waste was dumped in the landfill, only a small portion is converted into energy generation. There is a need to enhance waste intake capacity of waste to energy plant. There are many WTE like biomethanation, incineration, HTC etc which are efficient with negligible environmental impacts.
- To deal with the exponentially growing MSW, environmentally benign practices including infrastructure for collection, handling, sorting, processing and disposal for all types of waste along with appropriate and sustainable solid waste management technologies are need of the hour.

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Conflict of Interest

The authors do not have any conflict of interest.

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