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Application of EASEWASTE model for assessing environmental impacts from solid waste landfilling

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Abstract: Dumping sites or landfills are considered as foremost common option of waste management worldwide. Dumping sites, often not lined, represent a potential environmental issue causing a long-term risk to the environment and health. A number of computers model-based studies have described the solid waste collection and its management, but provide little information about the relative contributions regarding environmental impacts of landfilling especially in the context of developing world. The aim of study was to estimate environmental impacts from dumping site by using EASEWASTE model. A case study was carried out at an old and closed dumping site filled with mixed waste without bottom liner, no leachate collection and gas collection. On the basis of the existing dumping site investigation, a Mahmood Booti Dumping Site Scenario was developed, and related data of waste generation & composition was collected and added to assess environmental impacts. The results show that human toxicity via soil (9.14E+09 m^3 soil) had the highest potential impact, followed by global warming (8.83E+11 Kg CO_2-eq), eco-toxicity in water (6.25E+11 m^3 water), and eco-toxicity in soil (6.54E+10 m^3 soil). This is mostly caused by leaching of heavy metals from ashes (e.g. residues from roads cleaning and vacuum cleaning bags), batteries, paper and metals. The adopted risk analysis approach uses easily accessible computer aided models, for open dumping sites, appears to be a key tool to assist decision makers in establishing priorities for remediation action.

Introduction

Landfilling is least preferable choice in waste management hierarchy, but it is the most widespread waste disposal method globally (Mahmood et al. 2017). Management of solid waste is a prominent issue in developing countries (Singh and Raj 2018). In developing countries, the strategic decisions regarding waste management are mainly dependent on assumptions in preference to objective judgments because of limited availability of data, inexpert manpower and lack of expertise in solid waste management (SWM) (Marshall and Farahbakhsh 2013). Several developing countries have chosen new strategies for waste management and old traditional waste management practices are being discarded as new technologies are in the process of being deployed (Malinauskaite et al. 2017). The nature and scope of improvement towards environmental management and sustainability are highly dependent on the economic condition of the country.

Models regarding Life Cycle Assessment are established for assessing the environmental impacts from diverse waste systems and technologies. Recent studies focus mainly on the use of Life Cycle Assessment (LCA) in the environmental assessment of solid waste management particularly for developed countries (Thomsen et al. 2017) as for developing world (Noya et al. 2018) (Smol et al. 2020). In developing countries, solid waste composition is diverse and SWM practice still focuses on open dumping/landfilling (Laurent et al. 2014). Some LCA models are discussed as follow: **WISARD** (Waste Integrated Systems Assessment for Recovery and Disposal) was developed to estimate environmental impacts of household waste and assist decision makers regarding the policies of waste disposal (Winkler and Bilitewski 2007). **WRATE** (Waste and Resources Assessment Tool for the Environment) is being used by waste management organizations and it was developed for the UK Environmental Agency. The model is simple and easy to handle in comparison to other complicated

LCA models; though, a few studies described that it may cause misinterpretation sometimes (Gentil et al. 2010). **WASTED** (Waste Analysis Software Tool for Environmental Decisions) was established by collaboration of "Research Council of Canada" (NSERC) and Ryerson University. The baseline data utilized is extracted from Danish EPA, IVM and US EPA (Diaz and Warith 2006). **ORWARE** (Organic Waste Research) helps with organic fraction of solid waste and was developed in 1996. This Sweden model has limited usage and applicability (Vimpolšek et al. 2019). **UMBERTO** helps in visualizing material and energy flow systems and this model is mainly for industrial services and products (Laurent et al. 2014). **SIMAPRO** is mainly focused on a single material instead of complex system investigation (Winkler and Bilitewski 2007) and it is the most commonly used model accompanied by EASEWASTE (Grzesik 2017).

Among all these discussed LCA models, EASEWASTE is the most advanced model that was developed at Technical University of Denmark. It is easily accessible, flexible, and reliable as compared to other models. This model was established for assessing the entire resource utilization and environmental impacts of MSW by LCA (Fatima et al. 2019). LCA modeling of disposal sites is a challenging and complicated task because sufficient site-specific data are required which must represent all the relevant environmental and technical factors. Hence, all the required data are not always accessible, hence filling these gaps with the literature data from related existing landfills often becomes essential. However, this must be evaded as far as possible; otherwise, the LCIA results will not be completely representative of the actual landfill. Therefore, available data from landfills under study are often represented in a unit that does not fulfill the requirement of the used LCA model. For example, EASEWASTE includes data on material and energy inputs to be entered as an accumulated quantity expended over the LCA time period in relation to the unit weight of landfilled waste (e.g. kWh of electricity used in 100 years per ton of wet waste). Nevertheless, real data do not usually cover more than 2 to 3 decades of landfill processing and thus need to be complemented with data from rapid, limited-scale experiments and model calculations (Laurent et al. 2014).

EASEWASTE model is very helpful for waste planners & risk assessment managers to refine existing waste management systems (WMS) with regard to environmental efficiency, and for authorities to define regulations/guidelines and review various waste management strategies (Maalouf and El-fadel 2020). This model is mainly designed for MSW, and thus does not deal with commercial and demolition waste. The access to its database allows the users to measure the impacts of a built waste program using default data based on the factors that contribute to the total impacts (Grzesik 2017). EASEWASTE enables the user to provide comprehensive data for waste generation, waste composition together with fractions of materials and chemical characteristics, efficiencies in sorting, waste collection, and waste treatment techniques. The model reports data on impact categories like global warming, stored ecotoxicity, and spoiled groundwater resources and human toxicity (Fatima et al. 2019).

In developing countries like Pakistan, the complexity of the SWM has been boosted by rapid urbanization, high population, enhanced waste generation, lack of resources, and insufficient regulations (Majeed et al. 2018). Municipalities of Pakistan have always been blamed for providing the people in their authorities with inadequate services from waste collection to its disposal. The resulting disparity between the existing SWM system and the increasing need for expanded collection, treatment and disposal facilities contributes to the rising solid waste quantities within the urban environment creating unhygienic and unsightly conditions. The impacts are expected to gradually exceed and must be quantified in order to comprehend the degree of the problem and finding proper solutions (Majeed et al. 2018). One of the most significant knowledge gaps recognized by reviewing the literature is the lack of utilization of computer model to assess the environmental impacts in developing world. Literature review also demonstrates that application of EASEWASTE model on dumping site does not exist especially in Pakistani scenario. This probably will be the first study of its kind in Pakistan which incorporates the use of EASEWASTE for assessing the environmental impacts. This assessment of impacts would be very useful for risk assessment and management of contaminated sites.

In the present study, as discussed above, the EASEWASTE model is used to assess the environmental impacts from landfills/dumping site. This paper presents the structure of the model and demonstrates its functionalities on a case study based on the data from existing dumping site located in Lahore. The aim of this paper is to evaluate the impacts arising from dumping site using computer aided model like EASEWASTE for proper waste management. Following are the objectives of current study:

- To assess the suitability of LCA modeling and, in particular, of the EASEWASTE model, for the environmental assessment of landfilling systems and technologies, with special focus on the impacts.
- To apply the model on existing dumping site to estimate the environmental impacts.

Material and Methods

The study involves the following steps:

Selection of the study area

The selected site, i.e., Mahmood Booti open dumping site (MBODS) is located in Lahore. Lahore is the second largest city in Pakistan having an area of 1,772 square kilometers (Figure 2). This site was selected because it is the oldest and authorized municipal disposal site of Lahore located between 31°36'31.80"N and 74°23'13.15"E; 3.5 km away from the River Ravi. The dumping site is located on an area of 32.0 ha.

Application & Structure of EASEWASTE Model

EASEWASTE was applied to existing dumping site in Lahore to see its applicability and impacts from the selected site.

Goal and Scope: Although EASEWASTE is a LCA model but in this study, it was applied only to assess environmental impacts from a closed dumping site. The purpose of this study is to evaluate environmental impacts by using EASEWASTE model.

Functional Unit: The model consists of functional unit. Functional unit in present study describes the total waste quantity dumped at existing dumping site. Waste is dumped without proper guidelines (without any bottom liner, leachate and gas collection system)

System Boundaries: In this study, boundaries only considered open dumping. Waste dumping site was closed so it is a post assessment of an area (Figure 3). The model has various modules and sub-models, each representing a process in a specific WMS, and these modules can be combined in a scenario to represent a total WMS. Waste generation, waste management, external processes and evaluation are the main modules in the model. EASEWASTE produces data on emissions (inventory) that are translated and aggregated into different categories of environmental impacts such as global warming, human & eco-toxicity and spoiled groundwater resources. Real data from the field have been applied in the present study, where possible.

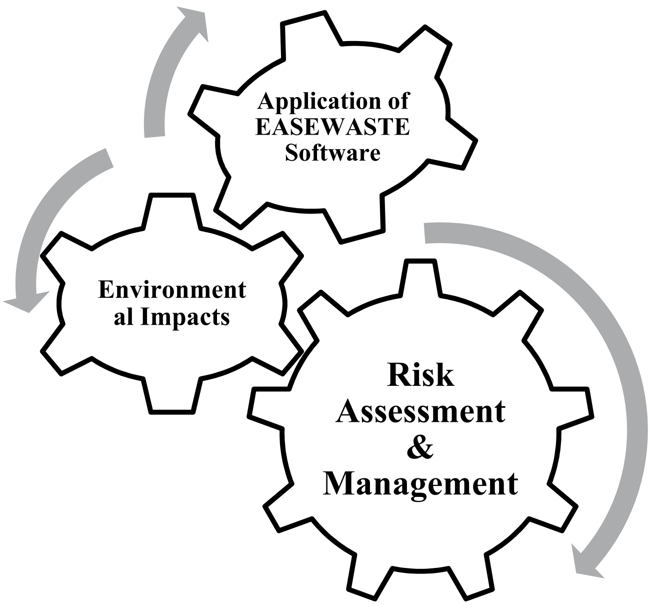

Fig. 1. Impacts assessed from EASEWASTE leads to Risk Assessment

Scenario Development and Data Input

The disposal practice in the selected site was open dumping of waste without any liner, gas and leachate collection system. The uncollected/untreated leachate and gas would produce emissions to surface water, groundwater and into air. Based on the existing dumping site investigation, a Mahmood Booti Dumping Site Scenario has been developed and related data of waste generation & composition have been collected and added to assess environmental impacts.

According to input data (Table 1), approximately the total waste dumped at the site was 13,000,000,00 tons and the height of waste heap was 20–25 feet. During the operational period of dumping site, approximately 1200–1500 tons/day was generated, collected, and dumped at the site. In EASEWASTE software, after waste generation category, there is waste management category. In waste management category, waste technology is sub-category. In waste technology, landfill mixed waste option is selected because Mahmood Booti Dumping site had mixed waste composition. Input data regarding leachate composition is presented in Table 2. Leachate samples were collected from open leachate pools (Figure 4) at the site and they were analyzed for physio-chemical parameters and heavy metals. So, actual values of heavy metals like Ni, Pb, Mn, Cr, Cd, Cu, and Zn were added into the software.

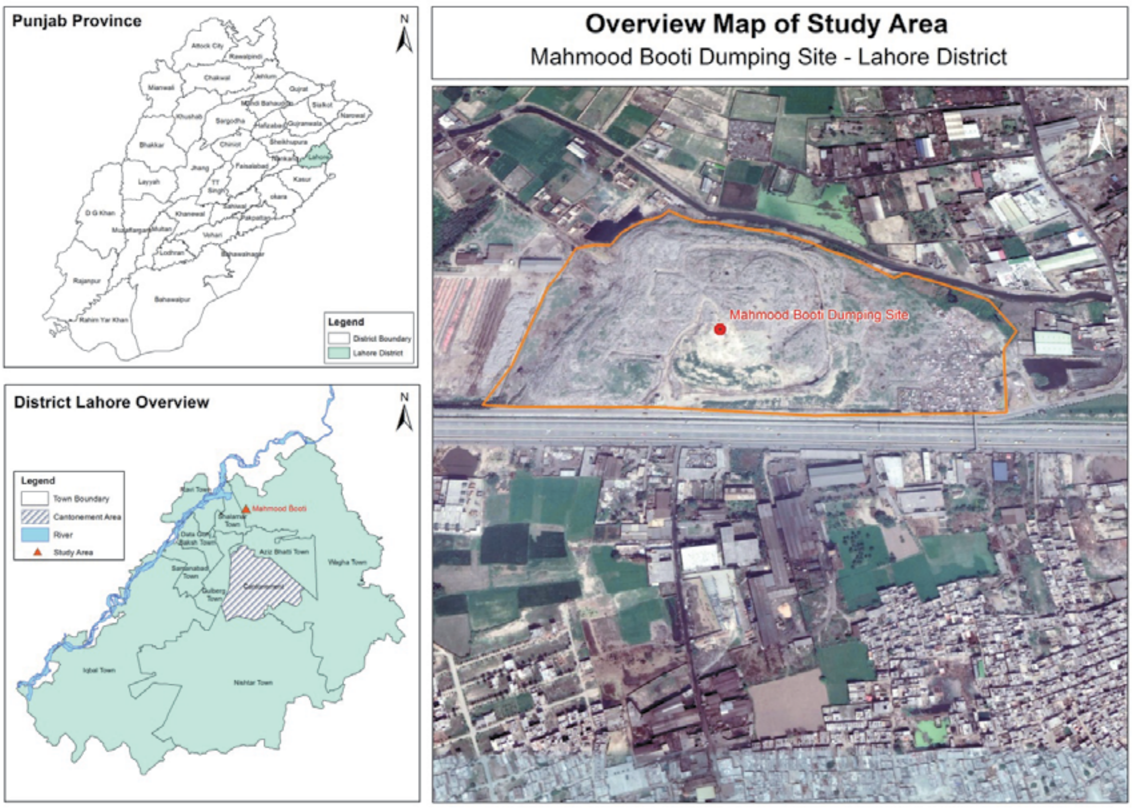

Fig. 2. Map of study area

Assessment of Environmental Impacts

The impact categories of EASEWASTE included Global Warming (GW), and Stratospheric Ozone Depletion (SOD). Toxicity-related impact categories included Eco-toxicity in soil (ETs) and in water chronic (ETwc), Human-Toxicity via soil (HTs), via water (HTw), and via air (HTa). The potential impact on groundwater resources is represented by the single category Spoiled Groundwater Resources (SGR) (Fatima et al. 2019) (Majeed et al. 2018). SGR calculation is based on the amount of groundwater that may be contaminated from an input of leachate.

Global warming is the ongoing rise of the average temperature of the Earth's climate system. Ozone depletion happens when gases are released into the atmosphere. Human toxicity refers to the degree of a substance (toxin or poison) which can harm the humans. Eco-toxicity refers to the levels and types of contaminants that cause harm to biota.

Results and Discussion

This section describes the results of the case study to illustrate different impacts determined from the EASEWASTE model.

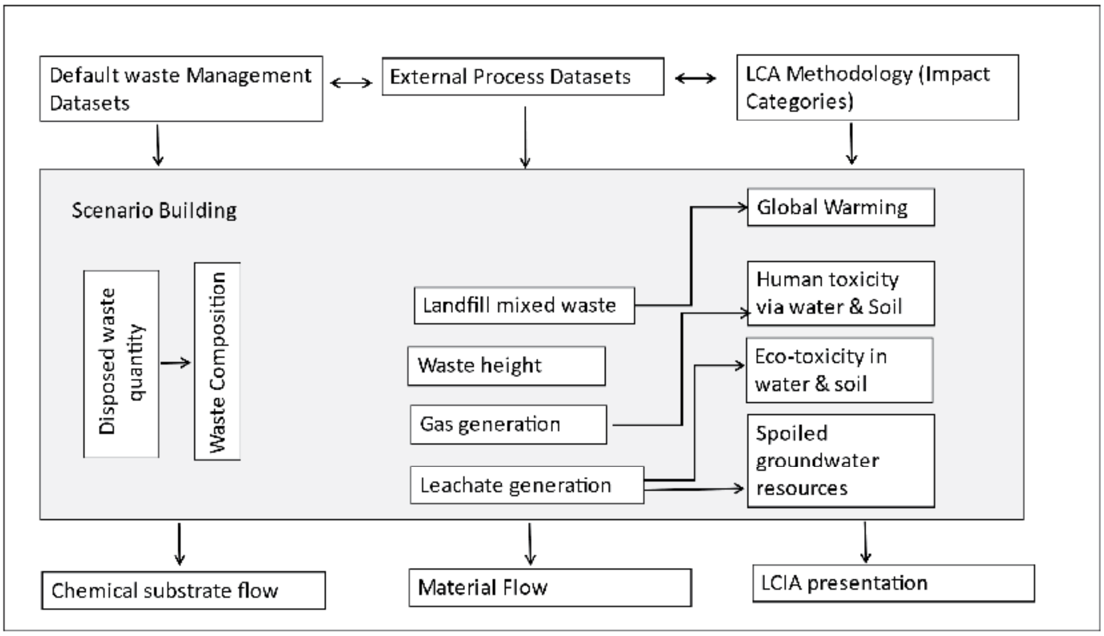

Fig. 3. Conceptual Structure of EASEWASTE (in context to present study)

Table 1. Input Data for waste composition and waste generation of Mahmood Booti Dumping Site

Waste Composition	Percentage (%)
Biodegradeable	63.46
Metals	0.04
Non-combustibles	1.82
Paper Cardboard	3.84
Pet	0.18
Naylon	9.77
Plastics	0.66
Tetrapak	0.94
Textile	7.05
Combustibles	3.69
Diaper	6.75
Electronics	0.02
Glass	0.85
Hazardous	0.91
Waste dumped at site	13, 000,000,00 tons waste
Waste heap	20–25 feet

EASEWASTE is LCIA model but this paper focuses mainly on the environmental impacts generated from the dumping site. The characteristics of MBODS represents that landfill open closure in the years 1996–2016. According to input data, approximately the total waste dumped at site was 13,000,000,00 tons and the height of waste heap was 20–25 feet. During the operational period of dumping site, approximately 1200–1500 tons per day was generated, collected, and dumped at the site. Figure 5 shows the waste composition of study area. Waste composition revealed a major portion of organic waste. Ramachandra et al. (2018) also exhibited that organics/biodegradable products have highest proportion in solid waste of dumping site.

MBODS is "non-engineered disposal site" because it has no bottom liners or side liners. The system for leachate collection and its proper treatment is not present at the site. The site is still active in terms of waste degradation that is not stable. During operational phase of Mahmood Booti site, it received about 1200–1500 tons/day of MSW and this quantity is approximately 30–40% of the overall daily MSW of Lahore. This dumping site managed the waste collected from the main towns of Lahore like "Shalimar Town", "Data Town", "Aziz Bhatti Town", and "Gulberg Town" (Alam et al. 2017, Alam et al. 2021).

In this study, total waste generation was calculated based on waste collected at dumping site on daily basis during its operational phase. Waste composition data were collected from Lahore Waste Management Company (LWMC) that is an authorized company to manage this selected dumping site.

Table 2. Input Data regarding leachate and its composition

Parameters	Mean value
Ni (ppm)	0.44133
Pb (ppm)	0.9113
Mn (ppm)	0.83863
Cr (ppm)	0.84105
Cd (ppm)	0.50133
Cu (ppm)	0.1024
Zn (ppm)	0.0934
Fe (ppm)	27.9

Impact Assessment

The environmental analysis shows the entire potential impacts to assess the current situation of the existing scenario and system. The most significant stage of the MBODS is the disposal stage for all potential impact categories, as it causes noteworthy contributions to human toxicity via soil and eco-toxicity in soil. The impact categories for environmental assessment are described in Table 3:

Global Warming [kg CO_2-eq]

In this research, global warming category was found with maximum environmental impact (8.83E+11 kg CO_2-Eq) from MBODS. The stratospheric ozone depletion due to the waste dumped at MBODS was 4.44E+06 Kg CFC11-eq. Analysis of several systems revealed that landfilling is the highest potential for the global warming category (Majeed et al. 2018) (Sharma and Chandel 2017) (Ramachandra et al. 2018). Global warming is a significant indicator that increases temperature in the atmosphere, which leads to global & regional climate change. The environmental issues arising from landfills/dumping sites were linked with gaseous emissions and waste composition. Large quantity of organic waste and high temperature leads to significant greenhouse (GHGs) emissions in the air. Decomposition of the organic content generates landfill gas (Majeed et al. 2018).

Main substances that contribute to global warming were methane (1.336E+12 kg CO_2-Eq), dichloromethane

Fig. 4. Leachate sampling points from selected dumping site

(7.936E+7 kg CO_2-Eq), carbon monoxide (3174 kg $C0_2$-Eq), and CFCs (tricholorofluromethane) (7.301E+09 kg CO_2-Eq). Greenhouse gases such as CO_2, CH_4, N_2O and CFCs had main contribution in the category of global warming because of the lack of gas collection system at site and gases released into the atmosphere. Liu, Sun, and Liu (2017) also illustrated this fact that poor collection efficiency leads to a considerable emission of GHG into the atmosphere. The substantial contribution in climatic change from landfilling has been positive as proven by previous studies (Maria, Góis, and Leitão 2020). The contributions were correlated with release of CH_4, CO_2 and N_2O into the environment. The CO_2 originated from fossil fuel has been taken into account. The atmospheric N_2O is released to the environment by CH_4 oxidizing bacteria. It is therefore noted that nitrification and denitrification are not the only processes that release N_2O but CH_4 would be responsible too (Rana et al. 2019)water, and soil pollution. This requires immediate attention to minimize the impact of solid waste on the existing environment and health. Generation of waste is directly influenced by economic development. Most of the municipal authorities in the developing countries are facing massive challenges in waste management in an effective and efficient manner. The present study aims to explore the life-cycle assessment methodology to determine the impact of municipal solid-waste management under different scenarios in Tricity regions of Chandigarh, Mohali, and Panchkula. The study analyzes the impacts of different potential waste management alternatives for Tricity area using life-cycle approach (LCA. The emission of CO is also very alarming as this gas has no direct impact on global warming but indirectly it affects this category a lot by formation of ozone and reaction with hydroxyl ion (Parkes et al. 2015).

The dumpsite of the study area is not properly managed and maintained disposal site. The waste was not dumped in proper cells and lifts. It was realized during the field survey that microbial activity of different phases was taking place at the same time. It is therefore assessed that different greenhouse gases were continuously emitted from dumpsite.

Other researchers have indicated that the projected impact potentials for global warming and gas emissions is primarily due to "organics" and "paper" (Ramachandra et al. 2018). To a large extent these rely on dispersed LFG emissions from the landfill surface. The other fractions of the waste produce most of the possible impacts measured for groups related to toxicity. The "organics" waste fraction has high methane probability and high degradability, and therefore high LFG quantities were produced by its degradation, which can be used to generate electricity. It contributes greatly to the global warming category being researched extensively and recorded (Buratti et al. 2015). Jagoda Gołek-Schild (2018) demonstrated that installation of thermal treatment plants at waste dumping site will not only reduce the amount of waste deposited, but will also assist in energy production.

Human Toxicity (via soil, water & air)

Results of the present study illustrate that human toxicity via soil was 9.14E+09 (m^3 soil), human toxicity via water was 7.03E+10 (m^3 water), human toxicity via air was 2.65E+15 (m^3 air) in MBODS. Findings of the present study revealed that human toxicity in soil is highest as compared to human toxicity in water and soil because soil is direct receptor of waste while the water and air are indirect receptors. The human toxicity is the probable damage that depends on toxicity level and the amount of substance encountered. It is an index that estimates the potential of a substance or chemical released in the atmosphere (Rana et al. 2019)water, and soil pollution. This requires immediate attention to minimize the impact of solid waste on the existing environment and health. Generation of waste is directly influenced by economic development. Most of the municipal authorities in the developing countries are facing massive challenges in waste management in an effective and efficient manner. The present study aims to explore the life-cycle assessment methodology to determine the impact of municipal solid-waste management under different scenarios in Tricity regions of Chandigarh, Mohali, and Panchkula. The study analyzes the impacts of different potential waste management alternatives for Tricity area using life-cycle approach (LCA

Soil is an essential component of any ecosystem. It interacts with biosphere, hydrosphere, and atmosphere. Soil pollution with heavy metals is a major threat to ecological integrity and human well-being (Mahmood and Malik 2014). Heavy metals play a very important role in this category, e.g., this study shows that nickel (1.498E7 m^3 soil), toulene

Table 3. Impact categories for Environmental Assessment

No	Impact Categories	Values
1	Global Warming 100 Years (EDIP97): [kg CO_2-eq]	8.83E+11
2	Stratospheric Ozone Depletion (EDIP97): [kg CFC11-eq]	4.44E+06
3	Human Toxicity via Soil (EDIP97): [m^3 soil]	9.14E+09
4	Human Toxicity via Water (EDIP97): [m^3 water]	7.03E+10
5	Human Toxicity via Air (EDIP97): [m^3 air]	2.65E+15
6	Ecotoxicity in Water, Chronic (EDIP97): [m^3 water]	6.25E+11
7	Stored Ecotoxicity in Water (EDIP): [m^3 water]	1.20E+15
8	Ecotoxicity in Soil (EDIP97): [m^3 soil]	6.54E+10
9	Stored Ecotoxicity in Soil (EDIP): [m^3 soil]	6.14E+09
10	Mahmood booti landfill leachate	1.20E+15
11	Spoiled Groundwater Resources: [m^3 spoiled water]	5.14E+12

(2.539E7 m^3 soil), tetrachloroethylene (1.714E8 m^3 soil), arsenic (4.952E7 m^3 soil), and cadmium (5.688E7 m^3 soil), are the main contribution to human toxicity via soil in MBODS. This includes the degradation of soil organic matter and lowering the fertility of upper soil layer due to erosion. Rana et al. (2019) also described that human toxicity is mostly caused by contaminants such as SOx, NOx, lead, dioxins, copper, chromium, nickel, cadmium, mercury, and arsenic.

Dumping of the waste like batteries, textiles, e-waste, ceramics, lead foils, packaging material and light bulbs, etc., greatly contributed to the release of various toxic substances like heavy metals in the study area. The lack of systems for collecting leachate and gas from landfills/dumping sites leads to the release of numerous toxic substances such as arsenic ion, chromium and zinc ion in water and some mercury in the air. Disposal of batteries releases lead and cadmium into the atmosphere. Heavy metals like Cr, Hg, Ni, As, Pb and Zn are of major concern as they might be detrimental to animals and humans at low levels and capable to accumulate in plants, soil, and animals (Majeed et al. 2018). Cr enters in the soil from the green glass and textile. Textile is a big fraction of household waste in the study area. Dumping of shoes and leachate is another cause of Cr in soil, water and air. Dumping of waste is a significant source of vinyl chloride. Bacterial degradation of tetrachloroethylene and trichloroethylene produces vinyl chloride (Rajaeifar et al. 2015).

Ecotoxicity Total (CTU)

Findings revealed that eco-toxicity in water was 6.25E+11 (m^3 water) and eco-toxicity in soil was 6.54E+10 (m^3 soil). These results exhibited the presence of toxic substances in water and soil and this is mainly due to dumping of waste at MBODS/landfill.

Ecotoxicity may be chronic or acute, aquatic or terrestrial, and it covers wide range of substances that might be hazardous for the environment. Several toxic substances like nickel (1.689E10 m^3 water), toulene (1.016E11 m^3 water), tetrachloroethylene (8.57E10 m^3 water), arsenic (1.83E09 m^3 water), cadmium (2.98E11 m^3 water), and benzene (6.348E8 m^3 water) are main contributions to eco-toxicity in water. Metals can enter kilns through MSW. Many of them are stored in clinker but the metals which are volatile get into air and then get back and pollute the water. Most are locked in the clinker, while metals that are partly or completely volatile are not. These metals may be mercury, lead and cadmium. Metals are present in paper, newsprints, wood, yard waste, metal cans and batteries, etc. (Popiţa et al. 2017) Previous investigation indicated that heavy metals such as manganese, zinc and cadmium have a maximum vulnerability for leaching into the soil (Mali and Patil 2016). The key source of other heavy metals like copper and zinc are four solid waste materials, like kitchen waste, ash, plastic, and paper. The concentrations of heavy metals in solid waste differ with seasonal fluctuations and are considerably higher in summers than in winters. Open dumping triggers ecotoxicity in both short- and long-term situations and may not provide a proper system for collecting leachate and gas. Zn, Cu, Ar, and Ni ions in leachate induce water supplies contamination while Vn, Cu, Zn and Hg are responsible for air pollution (Majeed et al. 2018).

Stored Toxicity

Results of the present study show that stored eco-toxicity in water was 1.20E+15 (m^3 water) and stored eco-toxicity in soil was 6.14E+09 (m^3 soil). The organic waste may be completely degraded or rendered inert in a landfill, but the waste still contains large quantities of substances that can allow long--term leaching, which relates to stored toxicity. It may conclude that half of the toxic substances end up in the water resources in the long run, while other half ends up in the soil (Maalouf and El-Fadel, 2019).

Spoiled Groundwater Resources

In this study, the quantity of spoiled groundwater resources was 5.14E+12 (m^3 spoiled water). The leachate generation rate was 1.20E+15 (m^3 leachate), this generation is due to annual infiltration estimated in mm per year. The leachate from landfill is generated by water infiltration. Leachate is produced during all the stages of landfill but often with varying quantities. These leachate quantities in landfill may vary with time because of several reasons such as various landfill stages, changes in top cover and seasonal variation (Guleria and Chakma 2019)a probabilistic human health risk assessment (HHRA).

These results show that contamination of groundwater with leachate is a very serious issue. Heavy metals like chromium (8.024E9 m^3 spoiled water), lead (9.369E9 m^3 spoiled water), nickel (8.024E9 m^3 spoiled water), and copper (8.024E9 m^3 spoiled water) are the main contributors in spoiled groundwater resources. The most relevant environmental factors linked to landfill leachate are groundwater and surface water pollution. Groundwater is a reliable and important natural resource for economic development and human life. Groundwater contamination is mainly caused by industrialization and urbanization which eventually evolved with the passage of time. Leaching of leachate from landfills, unless properly handled, creates a high risk to groundwater supplies. Leachate from dumping sites is a potential source of ground water contamination (Szymański and Janowska 2016). Earlier research found that landfill leachate highly affects the groundwater and surface water resources (such as ponds) in the surrounding of closed solid waste disposal site. Consequently, in majority of people living in adjacency to the dumping site, diseases such as diarrhea, hepatitis, stomach pain, dysentery etc. have often occurred (Maiti et al. 2016).

Conclusions

This paper describes the application of EASEWASTE (Environmental Assessment of Solid Waste Systems and Technologies) model for risk assessment approach. Literature review described several LCA models but EASEWASTE was selected for the present study as it is latest, reliable and user friendly and it has a very holistic approach for impacts assessment. The model permits the user to provide comprehensive data for waste generation, waste composition, material fractions and chemical properties, sorting efficiencies, waste collection, and waste treatment approaches. Mahmood Booti Open Dumping Site (MBODS) was selected because it is the oldest and authorized dumping site in Lahore. This site covers an area of 52 ha and contains about thirteen million tons of waste that was dumped there from 1996 to 2016. The waste composition illustrated that it is a mixed kind of waste. Our findings provide a quantitative impact assessment of Mahmood Booti dumping site/landfill. The assessment evaluated potential impacts for global warming (GW), ozone depletion (OD), human toxicity via soil (HTs), spoiled groundwater resources (SGR) and ecotoxicity in water chronic (ETwc). The largest impact potential was found for global warming, human toxicity via soil and water, ecotoxicity and spoiled groundwater resource. It can be concluded that environmental impacts (global warming, eco-toxicity, human toxicity, spoiled groundwater resources) associated with landfill sites can be highly reduced, if proper collection and treatment system for leachate and gas will be taken into consideration. GHG effect would be reduced, if all produced biogas was collected and consumed in a proper way.

It can be recommended that there should be proper gas collection system, otherwise landfill gases may migrate up via the top layer of the landfill and pollute the atmosphere. Similarly, the leachate can either be collected and taken to surface water or treated at a wastewater treatment plant; otherwise, the leachate can impact the groundwater supplies. The results conclude that among the numerous technical factors and environmental variables that affect landfill environmental assessment, the performance of the bottom liner, top cover, LFG, and leachate collection systems are important as they control environmental emissions. Management of gas and leachate contributes significantly to the environmental efficiency of the disposal sites/landfills. The application of these models to existing dumping sites greatly interprets that WMS can be designed in an environmentally sustainable manner where energy recovery processes lead to substantial pollution avoidance of emissions and resource savings. This model is a great decision supporting tool. The assessment of environmental impacts by using such models is very helpful for risk assessment and management of landfilling sites.

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