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Current Trends and Pressing Issues of Solid Waste Management in Developing Countries with Special Reference to Pakistan

Zubair Ahmad [1]

Abstract: *In South Asia, Pakistan ranks as the second largest state and stands sixth globally in terms of population. This research critically examines the solid waste management (SWM) system in Pakistan, employing a qualitative methodology to assess its effectiveness. The study begins with a broad overview of SWM issues in developing countries, focusing on Pakistan's specific challenges such as mismanagement, lack of innovative techniques, insufficient budget, and inadequate policies. It scrutinizes the SWM practices across all provinces, identifying open dumping, burning of solid waste, and industrial waste disposal in water streams as prevalent methods. These techniques are analyzed for their adverse impacts on human health and the environment, highlighting the urgent need for a more effective SWM system. The research underscores the importance of adopting sustainable practices and integrating comprehensive frameworks to improve SWM. By examining empirical data and employing a robust analytical framework, the study aims to provide actionable insights for policymakers and stakeholders to enhance the sustainability and effectiveness of SWM in Pakistan. The ultimate goal is to foster a system that aligns with global sustainability standards, ensuring better environmental and public health outcomes.*

Key Words: Solid Waste Management, Recycling, Disposal, Treatment, Open Dumping, Burning, Pressing Issues, Developing Countries

Introduction

Solid waste can be defined as anything that is considered filth, garbage, remaining, residue, or purposeless. However, it has been defined in the "Pakistan Environmental Protection Act 1997" as an object that is not of use and is intended to be disposed of or discarded. It includes any kind of substance, like liquid waste, agricultural waste, industrial waste, or waste of livestock, or it can be nuclear waste, hospital waste, or polyethylene waste. However, the definition of "management" is the tools that are required or utilized for the proper and reasonable execution of this waste for preserving the natural environment and population from the hazardous effects. Thereby, this article employs the qualitative research methodology to highlight the pressing issues with regard to "solid waste management in developing countries" in general and Pakistani provinces in specific because the rapidly increasing population requires the best management tools for an effective system of waste management. This study critically analyzes various studies and existing literature that is cited properly. The lens of qualitative research helps in finding out the pressing issues that have been collected from various articles and reports that are available on various most authentic sites, including Google Scholar, Research Gate, sites of Wiley, Taylor & Francis, Science Direct, Scopus, and Web of Science journals. However, there is a need to pinpoint the issues so that policies are made to manage the existing solid waste system. This article extracts doctrines from various studies and reports and assembles this piece as a contribution to the improvement of the solid waste management system of Pakistan. This paper has great significance due to its diverse nature. It is the first cutting-edge fresh research that provides a comparative analysis of the system of solid waste management in general to specific trends.

[1] Post-Doc Researcher, Department of Law, Economy, Management and Quantitative Methods (DEMM), University of Sannio, Italy.

▪ **Corresponding Author:** Zubair Ahmad (zahmad@unisannio.it)

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Pressing Issues of Solid Waste Management in Developing Countries

Solid waste management is an important element of environmental conservation and public health. Globally, rapid population growth, urbanization, and industrialization have exacerbated the challenges surrounding effective waste management. Solid waste management can be defined as the systematic and organized process of collecting, disposing of, treating, and recycling solid waste materials. It involves various activities with the goal to reduce the environmental impact of waste and ensure public health and safety (Guo et al., 2021). "The goal of solid waste management is to effectively and efficiently handle the waste generated by residential, commercial, industrial, and institutional sources. Following is the process of solid waste management that includes: Waste collection involves the collection and transportation of solid waste from various sources to a designated waste transfer station or landfill site." Waste can be collected through curbside pickups, communal bins, or specialized waste receptacles. However, proper waste segregation is essential to separate recyclable materials, hazardous waste, and organic waste from general waste.

Applying suitable disposal or recycling techniques is ensured by separating waste at the source (Azevedo et al., 2021).

Additionally, waste treatment uses a variety of methods to lessen the amount or toxicity of trash. Composting, incineration, pyrolysis, anaerobic digestion, and mechanical and biological treatment are a few examples of such procedures. The goal is to reduce waste's negative effects on the environment and, whenever feasible, recover resources (Kumar & Agrawal, 2020). "Waste disposal is the last phase in solid waste management." This usually entails the safe disposal of non-recyclable and non-compostable garbage in constructed sanitary landfills. To stop air pollution, disease transmission, and groundwater contamination, landfills should be appropriately planned and operated (Pujara et al., 2019).

Recycling, which involves gathering, processing, and turning items like paper, plastic, glass, and metals into new goods, is a crucial component of waste management. Resource recovery is the process of obtaining useful resources, such compost or energy, from garbage. These methods lessen the amount of landfill area, save energy, and save natural resources.

Enforcing rules and keeping an eye on waste management practices are essential for ensuring responsibility and compliance (França et al., 2020). Effective waste management is facilitated by the creation of waste management authorities or agencies, regular inspections, and sanctions for infractions. In order to reduce environmental pollution, safeguard public health, preserve resources, and advance sustainable development, proper solid waste management is crucial.

Adopting ethical trash disposal practices, putting recycling programs into place, and investing in cutting-edge waste treatment technology all require cooperation from governments, communities, businesses, and individuals (Shekdar, 2009).

The following are the main obstacles to solid waste management: Developing nations typically rely mostly on traditional waste management techniques like landfilling and open dumping. In addition to being bad for the environment, these outdated techniques make recycling and resource recovery more difficult. Important resources are frequently lost and the potential for recycling and composting is mainly unrealized due to inadequate trash sorting and separation facilities. Despite the existence of laws governing solid waste management in developing nations, its efficient application has been hampered by lax enforcement and few sanctions (Sakai et al., 1996). To guarantee compliance, waste management laws must be enforced more strictly and fines must be applied. Promoting proper waste disposal practices also requires raising public understanding of waste management techniques. "A key element of effective waste management is public participation." However, the general public is unaware of and does not comprehend the significance of appropriate trash disposal. A sense of responsibility for waste management can be fostered by promoting public participation through educational campaigns, seminars, and workshops (Gupta et al., 1998).

In developing nations, the potential for resource recovery is still mostly unrealized8. Resource recovery is inefficient due to a lack of a value chain for recycled materials, inadequate waste separation techniques, and a lack of recycling facilities (Daskalopoulos et al., 1998). The strain on landfills can be greatly lessened

and important resources can be preserved by establishing recycling facilities and encouraging sustainable waste management techniques. The absence of suitable infrastructure for garbage collection, segregation, "treatment," and disposal is one of the main issues. rubbish builds up in public areas, residential neighborhoods, and open landfills because most cities in developing nations lack an organized rubbish collection infrastructure. Inadequate infrastructure contributes to disease transmission, water body pollution, and environmental deterioration. With "waste pickers scavenging for recyclable materials," the unorganized4 sector contributes significantly to waste management in poor nations. However, waste pickers are at risk due to inadequate infrastructure, rules, and health and safety requirements. Better working conditions, equitable pay, and access to healthcare are all necessary for the formalization of the informal garbage sector (Allesch & Brunner, 2014).

A comprehensive strategy including infrastructure development, public awareness campaigns, policy reforms, and efficient enforcement of waste management laws is needed to address the problems associated with solid waste management in developing countries. Developing nations may reduce environmental pollution, safeguard public health, and create a cleaner and greener future by implementing sustainable waste management techniques and encouraging resource recovery. According to Nzediegwu and Chang (2020), developing nations must make investments in creating integrated waste management systems that cover waste collection, segregation, treatment, and disposal. To fully utilize solid waste as a resource, waste transfer stations, composting facilities, recycling facilities, and waste-to-energy plants must be established. It is essential to increase public understanding of the significance of appropriate waste management. The public should be educated about waste segregation, recycling, and composting through educational campaigns, seminars, and workshops. A culture of responsible waste disposal can be fostered by including communities and schools in waste management programs (Fadhullah et al., 2022).

Putting investment into waste management staff training and capacity building will improve their knowledge of contemporary waste management techniques. This entails educating waste workers, engineers, and legislators on how to separate waste, compost, recycle, and run contemporary waste management facilities. Stricter enforcement combined with updated and reinforced waste management laws can encourage compliance and hold organizations responsible for inappropriate waste disposal methods (Prajapati et al., 2021). The imposition of penalties for violations will act as a deterrent and facilitate the transition towards responsible waste management practices. Public-private partnerships can play a significant role in improving waste management practices in developing countries. Collaborations between the government, private companies, and NGOs can result in efficient waste collection, recycling, and resource recovery programs. “Such partnerships can also help in the development of innovative and sustainable waste management solutions” (Mojtahedi et al., 2021).

Solid Waste Techniques in Pakistan

There are various techniques that are utilized in Pakistan for the disposal of solid waste. This segment moves the direction of this article from general to specific means from the developing countries pressing issues in the context of solid waste management to the pressing issues with regard to the solid waste management in Pakistan. However, this segment critically inspects the means and methods that are employed in Pakistan for the disposal of the solid waste. This section enquires into the recycling conception in Pakistan, then disposal of household, industrial, hospital, agricultural, and poultry waste, their nature and composition.

Recycling of Solid Waste

The most prevailing definition of ‘recycling’ is that it is a method, process or the technique of reusing the solid waste material after they are passed from a process which is conducted in a proper and reasonable channel. Recently, the recycling is known as one of the best and globally recognised method for “the processing of solid waste for its utilisation in the future.” It is not a hard process to perform. However, it has greater impact on the business as it can provide the backbone for saving money to the various big and huge businesses (Mahar et al., 2019). The question which is of more importance is whether this technique is employed in Pakistani practice or not.

The fate of recycling is Pakistan is not as bright as it should be to cater the problems of solid waste and saving the money of government. The main and foremost issue which is lessening the employability of this procedure is the least presence of the innovative machinery which is required for the productivity and practicality of following the technique of recycling in Pakistan (Batool & Chaudhary, 2009).

This point of view is supported by a study conducted in Lahore, which is one of the biggest cities in Pakistan. This study seeks to examine the employability of recycling businesses. The study revealed that due to not properly execution of the technique, it is not bearing the fruits, which it should be boring (Michel, 2021). The study evinced that only 20.2% of the solid waste collected from Lahore is processed and passed by the procedure of recycling. Undoubtedly, this figure is very much less in comparison to the utilization of the recycling in developed countries that usually conduct the recycling of 81% of the collected solid waste. In Pakistan, due to recycling, the revenue collected is equal to the 800 million, while in America, due to recycling, the revenue generated was 82 billion dollars in 2021 and 91 billion dollars in 2022. There is an unimaginable gap between the revenue generations due to recycling in both countries. In Pakistan, the junk shoppers and scavengers gain nearly 20% and 22%, respectively (Fadhullah et al., 2022).

However, the main problem in Pakistan in the context of recycling is that the industries are not focusing on the employability of the recycling processes which is not a good omen because if the recycling is employed by the industries in Pakistan, it will definitely generate a handsome revenue of not less than 1 billion dollars approximately (Yasin et al, 2017). As in America, nearly 681,000 jobs, 5.5 billion dollars tax revenue and 38.7 billion dollars in wages is accounted by the industrial assistance in context of utilisation of the recycling (Michel, 2021). Consequently, Pakistani practice should seek into American practice with regard to recycling.

Treatment with Domestic and Industrial Solid Waste

In Pakistan, the domestic waste is disposed by the very conventional and old method in the modern world which is the open dumping. This method is among the methods which face severe criticism due to its effect to the public health and environment. In practice, in Pakistan, open dumping is synonymous to throwing of the domestic waste on the open lands which are present near the house (Ali & Kuroiwa, 2009). These open lands can be the grounds or any open areas. This is most trending in the rural areas of Pakistan while in the urban areas due to urban trends it is not much practicing but it is not stated that in urban areas the employability of the open dumping is non-existent; it exists but less in comparison with the rural trends. Moreover, the bad odor near the open dumping areas, the flood in streets and the spread of different diseases including malaria, hepatitis, and different viral, fungal, and bacterial infections, are not new things in Pakistan due to the utilization of these processes (Iqbal, 2022).

The second technique, which is in trend in Pakistan for the treatment of the solid waste in Pakistan, is the burning of the solid waste. In which the solid waste is collected in one or different open areas and is accumulated thereat, and it is openly burned. This is one of the most dangerous treatments with solid waste along with open dumping. These treatments badly affect the environment due to the emission of various gases, including methane, that cause the spread of various diseases like breathing issues. Further, the emission of carbon dioxide and carbon monoxide, which are the main causes of warming the environment, which is called global warming, is caused by the emission of these gases, and open burning is one of the causes of the production of these gases (Korai et al., 2017).

Incineration of industrial waste in Pakistan is not a new thing. In Pakistani hospitals, there are chambers "where the solid waste from the hospital is incinerated." Due to the stocking of the solid waste, it is sent for incineration, and there is emission of pollutants and toxins that badly harm the environment of the locality by destroying the good quality air. It has more negative effects on the quality of the local areas than the landfill contributes. It has great social impacts, including that the incineration of the solid waste adds to the air pollution and all the other forms of air pollution because the fumes produced by this process have toxicants that affect the population. It has been inspected and examined in a UK study conducted by Greenpeace, which stated that the people are affected by this process and they used to complain about the noise, smell, litter, and bad polluted environment (Sohoo et al., 2022).

In Pakistan, the solid waste pickers do incineration for the reduction of the size of the waste. Incineration for the reduction in the size of the solid waste in Pakistan is performed in nearby areas of Islamabad, and it is stated that it releases much harmful gases and adds in the carbon footprint. However, in Pakistan, there is no process for the calculation of carbon foot printing scientifically, so it can be guessed how incineration in adding in the carbon foot printing (Masood et al., 2014).

Treatment with Livestock and Agricultural Waste

Pakistan is an agrarian country; the economy of Pakistan is based on the revenue generated by agriculture. The general principle should be that the waste, whether produced by livestock or agriculture, must be reused. However, in Pakistan, the agricultural and livestock solid waste is treated differently.

The solid waste generated by the raw material after the crop harvesting is known as the agricultural waste. A large amount of waste generated by the crops is generally utilized by the livestock and poultry in Pakistan. The agricultural solid waste that is utilized by the livestock includes various objects (Masood et al., 2014). For example, Pakistan is considered the foremost and among the top exporters of rice. After the crop of rice is ready and is harvested, then the husking of rice is the process that is done in which the seed is separated from the covering. The husk separated during the process of husking is used as feed for the livestock, and it has commercial uses as well (Korai et al., 2017). Like, the cardboard is made by the husk. Moreover, the waste of crops is the best tool for the manufacturing of the paper. However, the main object is to have the objective; whether the country is utilizing her easily availed raw material for her commercialization and generation of revenue is the matter of main interest, which usually lacks in Pakistan at the practical level (Yasin et al., 2017).

Excreta or dung generated by the livestock is a solid waste, and there are various methods for the disposal of this solid waste. The excreta is considered one of the best fertilizers for the crops, and it is used for agricultural purposes because it is considered organically rich. Moreover, in villages, the excreta of animals is used for the purpose of cooking because in rural areas there is no transportation of the natural gas, so people burn dried excreta for cooking food (Iqbal, 2022).

On a very small scale, in Pakistan, the biogas is prepared by the waste of livestock. The generation of biogas in Pakistan is not a new concept, as the farmyard for the preparation of biogas was established in 1959 in Sindh, Pakistan. Later, many policies were made and implemented in different years, but during 1974 and 1986, the policies for the flourishing of the business of producing biogas from the solid waste of animals were made to give full attention to this business (Ali & Kuroiwa, 2009). However, the initiative failed due to a lack of technology and finance as well. A new initiative titled "Rural Support Program Network" and "Pakistan Dairy Development Company" is working for the development of the biogas plant in rural areas of Pakistan. The farmers are given subsidies for the installation of these plants where the manure of not more than five buffaloes or cows is enough for the running of tiny plants because the biogas is one of the best gases, which is not only environment friendly but also has a minute impact on the health of humans (Sohoo et al., 2022). Hence, full heed is still required for the promotion of this program.

Pakistani Provinces and Employability of Solid Waste Management

The largest Pakistani province is Punjab with the population of nearly more than 127 million or 127,474,000 approximately. However, in census of 1998, it was estimated as 70 million. It means this largest province of Pakistan requires the best and effective system of solid waste management that practically affects the system of solid waste in the province. Moreover, this province of Pakistan is called as the agricultural hub as well as in parallel it is considered a province heavily loaded with the industrial burden. For example, Faisalabad is the major city of this province which is known for its industries of cotton and various other things. In these industries, the emission of effluent comprising various dyes and waste from the leather industries, require effective treatment but in Pakistan, these industries dispose the waste into the streams, ponds, rives, canals and all the waste resources (Aslam et al., 2022).

There is no proper system as it is required for Punjab. "Open dumping; burning of solid waste and disposal of industrial waste in the water streams" is the techniques which are employed in Punjab which is a reason to be worried. The province does not employ recycling. The main reason is the budget issues.

The budget in Punjab for effective solid waste management is not significant due to which the optimal and innovative techniques are not introduced in the system. A study conducted in Punjab states that due to mismanagement of solid waste in Punjab, there is increase in the accessible phosphorus for the crops (Salam et al., 2021).

The largest province area-wise is Baluchistan but this province has very less population other than rest of provinces. The population of Baluchistan is approximately 20 Million and precisely it is 20,634,606. However, the population of the province is bifurcated into the rural and urban areas but the rural population is much more than the urban population. The rural population is facing bad condition of the solid waste management (Akamal et al., 2021). The rural areas are encountered with very poor and miserable condition due to the mismanagement of solid waste. Government over time has tried to employ various polices which have never be resulted well due to inconsistent application. To this end, an action plan was actualized. There was awarding of the rewards based on different titles including: first, "Rewards to the 'Cleanest' Union Council" and second, "Rewards to Tehsils for each Excreta Safe union", third, there was another reward entitled "Rewards to Tehsils for each Litter Free union" and the fourth reward was "Rewards to Tehsils for each Foul Water Free union" (Atta, 2020).

Recently, the open dumping in the open areas and places is the fate of solid waste of this province. However, according to the Sanitation Action Plan, there has been directed to TMAs to provide and set the distinct trunks for the waste of non-recycle and recyclable nature. TMAs are endeavoring to not permit the use of plastic bags. However, there are not strict actions (Salam et al., 2022).

The least developed province of Pakistan is Khyber Pakhtunkhwa (KPK) and the population of this province is nearly 35 Million containing 48 percent of women and 52% of the male population and according to 1998 census, the population was 17 million. Solid waste management of this province is not properly handled. The domestic agricultural and industrial waste is not properly disposed in this province. The population of KPK is not much education as they are not educated towards the solid waste management; therefore, the poor management has become the fate of this province of Pakistan (Aslam et al., 2022).

For last three decades, the province has been encountered with the terrorism, hence its resources has been destroyed as well as it has greatly impacted the poor management of solid waste. A report on Abbottabad condition of solid waste has been published by "International Union for Conservation of Nature" which "revealed that the status of solid waste management is worst." The report stated that more than 85% of the budget of management of "Havelian" and "Abbottabad Tehsil" used in giving the salaries and other additional packages of the officials (specifically superiors). Nearly 200 tons of waste is produced in the district per day. Due to negligent and ineffective management, it is not administered properly (Aslam et al., 2022).

The population of Sindh is 54 million and precisely it is 54,858,515. However, the solid waste management condition in this province is very bad. It has been revealed by the statistics that large amount of budget is spent only on the management of the sewerage system leaving not more than 1% of the entire budget for the solid waste management (Yousafzai et al., 2020). The results of a study has revealed that the province has no facility of management of solid waste as only 20% of the entire province is entertaining so-called system while rest of 80% of the province has no facility of solid waste management. However, "there is presence of huge level of disparity as 1% of the rural areas are enjoying the facility but 47% of urban areas have the facility of system of management of solid waste. The system of management of solid waste in Karachi is also worst." Even in the posh areas like cantonment, the management has employed their private people for the management of solid waste (Aslam et al., 2022).

Conclusion

The system for management of solid waste in developing countries in comparison with the system of developed countries is worst. There are no implementation of effective policies or any stringent laws. Neither the system is as effective to cope with the problems of solid waste management, nor has the government been employing the best management techniques or increasing the budgets to deal with the management system. Due to which, the system is failing day by day due to the increase of urbanization,

which is increasing the population density of these countries. More specifically, in Pakistan, there is no policy management or introduction of new innovative techniques and technologies for the proper management of systems. "Open dumping, burning of the solid waste, and disposal of industrial waste" in the water routes or streams is the current practice and trend, and such practices are not only contaminating the environment but also affecting the health of the public. It is not cared that either the current trends are heating the environment by global warming or the health of the public is affecting. It is to submit that "there is need for a proper and effective management system for solid waste" because it can generate revenue and improve the condition of a country if properly executed.

References

Ali, M., & Kuroiwa, C. (2009). Status and challenges of hospital solid waste management: case studies from Thailand, Pakistan, and Mongolia. *Journal of Material Cycles and Waste Management*, *11*(3), 251–257. https://doi.org/10.1007/s10163-009-0238-4

Allesch, A., & Brunner, P. H. (2014). Assessment methods for solid waste management: A literature review. *Waste Management & Research*, *32*(6), 461–473. https://doi.org/10.1177/0734242x14535653

Aslam, S., Ali, F., Naseer, A., & Sheikh, Z. (2022). Application of material flow analysis for the assessment of current municipal solid waste management in Karachi, Pakistan. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *40*(2), 185–194. https://doi.org/10.1177/0734242x211000427

Atta, U., Hussain, M., & Malik, R. N. (2020). Environmental impact assessment of municipal solid waste management value chain: A case study from Pakistan. *Waste Management & Research: The Journal of the International Solid Wastes and Public Cleansing Association, ISWA*, *38*(12), 1379–1388. https://doi.org/10.1177/0734242X20942595

Azevedo, B. D., Scavarda, L. F., Caiado, R. G. G., & Fuss, M. (2021). Improving urban household solid waste management in developing countries based on the German experience. *Waste Management (New York, N.Y.)*, *120*, 772–783. https://doi.org/10.1016/j.wasman.2020.11.001

Batool, S. A., & Chuadhry, M. N. (2009). The impact of municipal solid waste treatment methods on greenhouse gas emissions in Lahore, Pakistan. *Waste Management (New York, N.Y.)*, *29*(1), 63–69. https://doi.org/10.1016/j.wasman.2008.01.013

Daskalopoulos, E., Badr, O., & Probert, S. D. (1998). An integrated approach to municipal solid waste management. *Resources, Conservation and Recycling*, *24*(1), 33–50. https://doi.org/10.1016/s0921-3449(98)00031-7

Fadhullah, W., Imran, N. I. N., Ismail, S. N. S., Jaafar, M. H., & Abdullah, H. (2022). Household solid waste management practices and perceptions among residents in the East Coast of Malaysia. *BMC Public Health*, *22*(1), 1. https://doi.org/10.1186/s12889-021-12274-7

França, A. S. L., Amato Neto, J., Gonçalves, R. F., & Almeida, C. M. V. B. (2020). Proposing the use of blockchain to improve the solid waste management in small municipalities. *Journal of Cleaner Production*, *244*(118529), 118529. https://doi.org/10.1016/j.jclepro.2019.118529

Guo, W., Xi, B., Huang, C., Li, J., Tang, Z., Li, W., Ma, C., & Wu, W. (2021). Solid waste management in China: Policy and driving factors in 2004–2019. *Resources, Conservation, and Recycling*, *173*(105727), 105727. https://doi.org/10.1016/j.resconrec.2021.105727

Gupta, S., Mohan, K., Prasad, R., Gupta, S., & Kansal, A. (1998). Solid waste management in India: options and opportunities. *Resources, Conservation, and Recycling*, *24*(2), 137–154. https://doi.org/10.1016/s0921-3449(98)00033-0

Iqbal, A., Abdullah, Y., Nizami, A. S., Sultan, I. A., & Sharif, F. (2022). Assessment of Solid Waste Management system in Pakistan and sustainable model from environmental and economic perspective. *Sustainability*, *14*(19), 12680. https://doi.org/10.3390/su141912680

Korai, M. S., Mahar, R. B., & Uqaili, M. A. (2017). The feasibility of municipal solid waste for energy generation and its existing management practices in Pakistan. *Renewable and Sustainable Energy Reviews*, *72*, 338–353. https://doi.org/10.1016/j.rser.2017.01.051

Kumar, A., & Agrawal, A. (2020). Recent trends in solid waste management status, challenges, and potential for the future Indian cities – A review. *Current Research in Environmental Sustainability*, *2*, 100011. https://doi.org/10.1016/j.crsust.2020.100011

Mahar, A., Malik, R. N., Qadir, A., Ahmed, T., Khan, Z., & Khan, M. A. (2019). Review and analysis of current solid waste management situation in urban areas of Pakistan. In *Proceedings of the international conference on sustainable solid waste management* (Vol. 8, p. 36). Citeseer.

Masood, M., Barlow, C. Y., & Wilson, D. C. (2014). An assessment of the current municipal solid waste management system in Lahore, Pakistan. *Waste Management & Research: The Journal of the International Solid Wastes and Public Cleansing Association, ISWA*, *32*(9), 834–847. https://doi.org/10.1177/0734242X14545373

Michel Devadoss, P. S., Pariatamby, A., Bhatti, M. S., Chenayah, S., & Shahul Hamid, F. (2021). Strategies for reducing greenhouse gas emissions from municipal solid waste management in Pakistan. *Waste Management & Research: The Journal of the International Solid Wastes and Public Cleansing Association, ISWA*, *39*(7), 914–927. https://doi.org/10.1177/0734242X20983927

Mojtahedi, M., Fathollahi-Fard, A. M., Tavakkoli-Moghaddam, R., & Newton, S. (2021). Sustainable vehicle routing problem for coordinated solid waste management. *Journal of Industrial Information Integration*, *23*, 100220. https://doi.org/10.1016/j.jii.2021.100220

Nzediegwu, C., & Chang, S. X. (2020). Improper Solid Waste Management Increases Potential for COVID-19 Spread in Developing Countries. *Resources, Conservation and Recycling*, *161*, 104947. https://doi.org/10.1016/j.resconrec.2020.104947

Prajapati, P., Varjani, S., Singhania, R. R., Patel, A. K., Awasthi, M. K., Sindhu, R., Zhang, Z., Binod, P., Awasthi, S. K., & Chaturvedi, P. (2021). Critical review on technological advancements for effective waste management of municipal solid waste — Updates and way forward. *Environmental Technology & Innovation*, *23*, 101749. https://doi.org/10.1016/j.eti.2021.101749

Pujara, Y., Pathak, P., Sharma, A., & Govani, J. (2019). Review on Indian Municipal Solid Waste Management practices for reduction of environmental impacts to achieve sustainable development goals. *Journal of Environmental Management*, *248*, 109238. https://doi.org/10.1016/j.jenvman.2019.07.009

Sakai, S., Sawell, S. E., Chandler, A. J., Eighmy, T. T., Kosson, D. S., Vehlow, J., van der Sloot, H. A., Hartlén, J., & Hjelmar, O. (1996). World terends in municipal solid waste management. *Waste Management (New York, N.Y.)*, *16*(5–6), 341–350. https://doi.org/10.1016/s0956-053x(96)00106-7

Salam, M., Alam, F., Dezhi, S., Nabi, G., Shahzadi, A., Hassan, S. U., Ali, M., Saeed, M. A., Hassan, J., Ali, N., & Bilal, M. (2021). Exploring the role of Black Soldier Fly Larva technology for sustainable management of municipal solid waste in developing countries. *Environmental Technology & Innovation*, *24*, 101934. https://doi.org/10.1016/j.eti.2021.101934

Salam, M., Shahzadi, A., Zheng, H., Alam, F., Nabi, G., Dezhi, S., Ullah, W., Ammara, S., Ali, N., & Bilal, M. (2022). Effect of different environmental conditions on the growth and development of Black Soldier Fly Larvae and its utilization in solid waste management and pollution mitigation. *Environmental Technology & Innovation*, *28*, 102649. https://doi.org/10.1016/j.eti.2022.102649

Shekdar, A. V. (2009). Sustainable solid waste management: An integrated approach for Asian countries. *Waste Management*, *29*(4), 1438–1448. https://doi.org/10.1016/j.wasman.2008.08.025

Sohoo, I., Ritzkowski, M., Guo, J., Sohoo, K., & Kuchta, K. (2022). Municipal Solid Waste Management through Sustainable Landfilling: In View of the Situation in Karachi, Pakistan. *International Journal of Environmental Research and Public Health*, *19*(2), 773. https://doi.org/10.3390/ijerph19020773

Yasin, H., Usman, M., Rashid, H., Nasir, Dr. A., & Randhawa, Dr. I. A. (2017). Alternative approaches for solid waste management a case study in faisalabad pakistan. *Earth Sciences Pakistan*, *1*(2), 07–09. https://doi.org/10.26480/esp.02.2017.07.09

Yousafzai, M. T., Nawaz, M., Xin, C., Tsai, S.-B., & Lee, C.-H. (2020). Sustainability of waste picker sustainopreneurs in Pakistan's informal solid waste management system for cleaner production. *Journal of Cleaner Production*, *267*, 121913. https://doi.org/10.1016/j.jclepro.2020.121913