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Original Article

Analyzing Occupational Hazards of Top Turn Operator in Compost Factories by JHA Method (Case Study: Halgheh Darreh Landfill and Treatment Center in Karaj)

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Abstract

Background: There are biologically harmful factors in waste management and, if neglected, they can bear detrimental consequences for the organization and its staff. Regarding the importance of the healthcare of the personnel working in waste management, this study has been conducted to identify and assess the sanitary and safety hazards threatening Top Turn operators working in urban compost waste factories.

Methods: In this sectional-descriptive study which was conducted in Karaj's Waste Management Methods: Organization Compost Factory in the year 2021, job hazard analysis (JHA) method was used in order to calculate the sanitary and safety risk caused by deleterious factors. First, the job in mind was selected and its responsibilities as well as the degree and probability of each risk factor were specified; then the risks were assessed according to risk assessment matrix based on MIL-STD-882B standard.

Results: A total of 8 risk factors were identified for the top turn operator, and respectively 2 factors were ranked as unacceptable, 4 factors as undesirable, 2 factor as acceptable but needing review. Using the JHA method the sanitary and safety hazards can be assessed and ranked proportionate to the risk level.

Conclusion: Regarding the importance of sanitary hazards, in addition to identifying and assessing them, it is suggested that controlling measures be carried out in order to reduce and repress risk levels so that the related occupational accidents and diseases and, as a result their heavy expenses can be prevented.

Keywords: Waste management, Top turn operator, Occupational hazards, Compost factory

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Introduction

Household waste, often mixed with residual hazardous chemicals widely used in industries and homes, has intensified the challenges of waste collection and disposal. The presence of approximately 48 000 types of residual chemicals in urban waste, including 500 known carcinogens, underscores the concern that the diverse composition of trash contributes to a range of environmental issues.[1] Violating regulations on residual waste is a serious offense in most countries, punishable by heavy fines and legal prosecution by local authorities and state courts.[2] Urban solid waste poses a great environmental threat in both developed and developing countries. The spread of various diseases, including hydatid cysts, skin disorders, leishmaniasis, and chronic cancers, has been linked to urban waste and its dispersion in water, soil, and air. Inadequate waste management contributes to environmental pollution, unpleasant odors, the proliferation of insects, rodents, and worms, and the transmission of infectious diseases.[3] Therefore, the proper collection and disposal of waste are crucial for directly and indirectly reducing sanitary hazards and environmental damage.[4] One of the challenges of compost production in our country is the high liquid content in urban waste,

which results in the generation of large amounts of leachate.[5] Due to improper separation of waste and the presence of inorganic materials in the large volume of waste entering compost factories, the resulting leachate contains microbial contaminants and various chemical pollutants throughout different treatment stages.[6] In the development of compost industries using mixed waste, social and environmental health may be at risk unless proper health measures are strictly followed.[7] One of the key concerns of managers is identifying and managing sanitary hazards and risks.[8, 9] Various methods have been developed to identify hazards in the workplace, with job hazard analysis (JHA) being an effective approach for detecting and preventing risks before they arise. The recognition of hazards and risks is the most critical component of any safety or sanitary program or system.[10] First, hazards and risks must be identified and addressed accordingly to regulate safety and sanitary goals and plans. The more accurately risks are identified, the more effective the performance system will be. In general, occupational risk factors can be classified into five categories: chemical, physical, biological, ergonomic, and psychological.[11] Municipal landfills and recycling centers can act as potential sources of fungal aerosol dispersion.[12] The National Research Council (NRC) of America[13] defines risk assessment as 'the process of determining potentially adverse sanitary effects of exposure to environmental risks.[14] The JHA is a precise and systematic method for identifying and assessing existing or potential hazards and risks in any process or occupation. This approach involves breaking down an occupation into consecutive stages, identifying the risks at each stage, calculating their risk values, and finally proposing control measures.[15] The usefulness of the JHA lies in its role as a guide for risk assessors, enabling them to use checklists to evaluate the implementation of control measures aimed at reducing workplace risks.[16]

Karaj is a metropolis in Iran and the 22nd most populous city in the Middle East, located at the foothills of the central Alborz Mountains.[17] The city's waste landfill and treatment center, Halgheh Darreh, spans over 110 hectares and serves as the only waste disposal site for Alborz county.[18] Every day, more than 1500 tons of waste are transported to Halgheh Darreh, with approximately 800 tons originating from other cities within Alborz county.[19] Assessing sanitary and safety risks is crucial for controlling the hazards of an infectious landfill environment and mitigating its detrimental effects on workers' health.[20] A compost turner machine is used to aerate and stir raw compost materials, which are stacked on the ground.[21] Proper aeration and stirring play a vital role in compost fertilizer production.[22] Adequate aeration enhances the function of aerobic bacteria, while smooth and uniform stirring ensures consistency in the compost's quality.[23] Therefore, using efficient compost turners significantly improves both the quality and speed of compost production, leading to a more homogeneous final product.[24] In compost fertilizer production, after the crushing stage, materials are stacked in predetermined ratios and periodically stirred and aerated using a turner machine.[25] During this process, essential additives may be incorporated to enrich the compost based on specific requirements. If waste separation plants only remove dry waste, merely 5% of total waste is diverted from landfills on average. However, utilizing compost turners can prevent the disposal of up to 70% of wet waste, significantly reducing landfill accumulation.[26] Despite the known advantages of compost fertilizer production—such as reducing waste management costs and minimizing environmental risks—special attention must be given to the health of compost turner operators. Due to their prolonged exposure to aerated waste, assessing the occupational risks faced by this group is essential in the field of waste management.[27-31] At the compost factory in Karaj, compost turners aerate fertilizer stacks, exposing operators to waste-related hazards and diseases for extended hours (Figure 1). Since the waste management cycle is both costly and labor-intensive, failure to properly identify and mitigate hazards can lead to significant financial and operational losses. This study aimed to analyze the occupational hazards of top-turner operators at the Halgheh Darreh Landfill and Treatment Center in

Figure 1. Top Turn Machine in Operation at the Halgheh Darreh landfill

Karaj using the JHA method.

Materials and Methods

The present study, which is a sectional-descriptive study was done in the compost plant of the landfill and trend treatment center of Halgheh Darreh in Karaj in the year 2021(Figure 2).

The present study is a sectional-descriptive study conducted in 2021 at the compost plant of the Halgheh Darreh Landfill and Treatment Center in Karaj (Figure 2). The research focused on assessing the occupational hazards of top-turn machine operators using the JHA risk assessment method. The study was conducted in five phases: Formation of the Risk Assessment Team – In the first phase, after defining the scope and objectives of the risk assessment, a risk assessment team was assembled. This team included environmental health and HSE experts with experience in waste management, along with the head of the Bureau of Waste Dumping and Treatment, to identify and evaluate health risks and their potential consequences. Job Breakdown and Risk Identification – In the second phase, the top-turn machine operator's job was divided into its specific tasks, and the associated risks for each task were identified. Given the high potential for exposure to hazardous materials, this job was prioritized for risk assessment. Each task within an occupation may pose different risks, necessitating a comprehensive understanding of the job. At this stage, all potential hazards in each step of the work process were identified. Risk Probability and Severity Assessment – In the third phase, the likelihood and severity of identified risks were analyzed. Using Table 1, which outlines the probability of

Table 1. Probability of Incidents Related to Identified Risks in the JHA Method

Probability Description	Probability Level	Probability
It happens frequently.	A	$X>10^{-1}$ Repetitively
It occurs several times during the lifetime of the system.	B	$10^{-3}<X<10^{-1}$ Probable
It occurs occasionally during the lifetime of the system.	C	$10^{-3}<X<10^{-2}$ Occasional probability
The probability of its occurrence during the lifetime of the system is very low.	D	$10^{-4}<X<10^{-3}$ Low probability
The probability of its occurrence during the lifetime of the system is so low that it can be considered as zero.	E	$X<10^{-4}$ Improbable

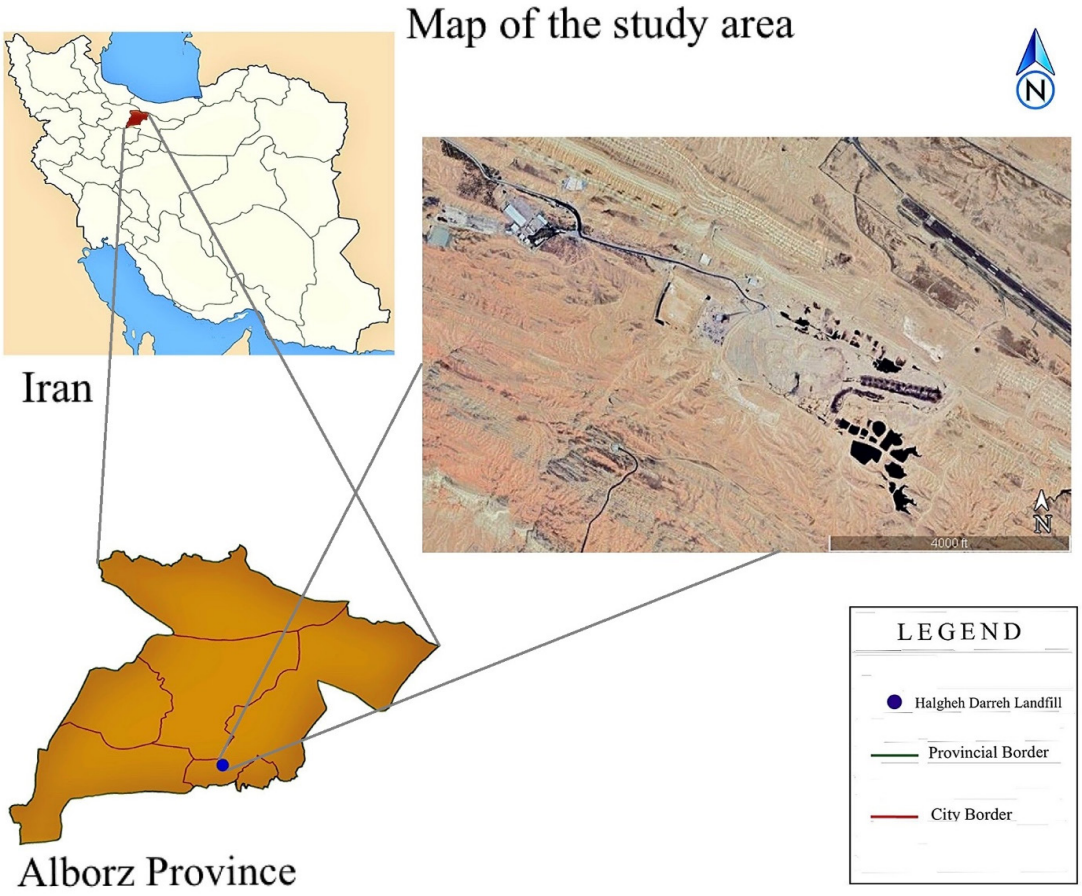

Figure 2. Map of the Study Area (Halgheh Darreh)

incidents related to identified risks in the JHA method, the probability values of each risk were determined.[32]

Using Table 2, which outlines the intensity and extent of detrimental consequences for humans resulting from accidents in the JHA method, the severity value of each risk can be determined.

Next, according to the risk assessment matrix based on the MIL-STD-882B standard (Table 3), the risks were ranked, and the assessment criteria were applied.

We classified the risks according to Table 4, categorizing them into four distinct groups.

Results and Discussion

The hazards identified for the task under consideration were documented, along with their consequential risks. The probability of each risk was determined using Table 1, followed by the severity assessment based on Table 2. After obtaining these values, the risk level was determined using the risk assessment matrix in Table 3. Finally, using Table 4, the risk criterion was established.

The risks were classified into four categories as follows:

1) Unacceptable – Marked in red
2) Undesirable – Marked in yellow
3) Acceptable but requiring revision – Marked in green
4) Minor – Marked in blue

According to Table 5, control measures were proposed for each risk category to mitigate potential hazards and improve workplace safety.

This study aimed to identify and assess sanitary and safety hazards and risks. A total of eight risks were identified, of which: (1) Four risks (25% RF) were classified as unacceptable. (2) Two risks (50% RF) were categorized as undesirable. (3) Two risks (25% RF) were considered acceptable but requiring review (Figure 3).

Vinti et al demonstrated that assessing risks in landfills helps reduce safety and sanitary consequences. They also highlighted the association between landfill work and abnormal deaths, increased prevalence of various cancers,

Table 2. Intensity and Extent of Detrimental Consequences for Humans Resulting From Accidents in the JHA Method

Description	Class	Type of Risk
Mortality or system destruction	1	**Disastrous**
Injuries, occupational diseases or the damage to the system is severe	2	**Critical**
Injuries, occupational diseases or damage to the system is low	3	**Borderline**
Injuries, occupational diseases or damage to the system is very low	4	**Minor Effects**

Table 3. Risk Assessment Matrix Based on MIL-STD-882B standard

		Probability				
		A	B	C	D	E
Intensity	1	1A	1B	1C	1D	1E
	2	2A	2B	2C	2D	2E
	3	3A	3B	3C	3D	3E
	4	4A	4B	4C	4D	4E

Table 4. Decision Criteria Based on Risk Index

Risk Classification	Risk Criterion
1A-1B-1C-2A-2B-3A	Unacceptable
1D-2C-2D-3B-3C	Undesirable
1E-2E-3D-3E-4A-4B	Acceptable but needs revision
4C-4D-4E	Minor

Table 5. Assessment of occupational Hazards of Top Turn Operator in Compost Factor

Row	Task Description	Dangers	Consequences	Probability	Intensity	Risk Level	Risk Criterion	Control Actions
1	Operation	Noise	Hearing loss	A	4	4A	Acceptable but needs revision	Using ear plugs
		Dust	Respiratory exposure, shortness of breath, pulmonary sensitivity	A	2	2A	Unacceptable	Conduct annual occupational medicine examinations and use chemical cartridge respirator
		Accident with a transporter	Death, disability, fracture, crushing, dislocation	C	2	2C	Undesirable	Using bright work clothes – Not being in the blind spots of machines
		Accident	Death, disability, fracture, crushing, dislocation, musculoskeletal disorders	C	2	2C	Undesirable	Using bright work clothes – Not being in the blind spots of machines
2	Operation	Animal bites	Injury, bleeding, swelling	C	2	2C	Undesirable	Completely enclosing the infected landfill area and ensuring that the entrance door is closed
3	Operation	Sharp objects	Skin cuts on the fingers or toes, superficial or deep bleeding	C	2	2C	Undesirable	Use resistant work gloves and safety shoes
		Exposure to methane and CO_2 gas	Weakness, dizziness, headache, nausea, vomiting, cardiovascular, respiratory and nervous problems	A	2	2B	Unacceptable	Use chemical cartridge respirator
		Shift work	Emotional exhaustion, depression, decreased job motivation	A	4	4A	Acceptable but needs revision	Work in Shift - allocation of special benefits

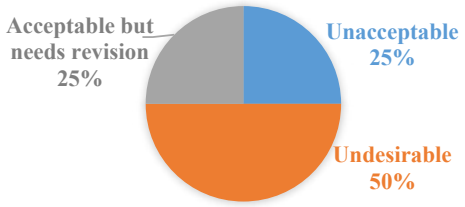

Figure 3. Occupational Hazards of Infectious Waste Landfill Worker

respiratory diseases, communicable diseases through waste transport, reduced mental health, and a rise in cardiovascular diseases.[33] Omidvari and Shahbazi applied the prioritization of safety, health, and environmental (SHE) risks in their study. Their findings indicated that biological hazards had the highest risk priority ranking, while physical hazards posed the least risk to humans.[34] Every research project is a logical, systematic, and scientific approach aimed at answering a specific question or solving a problem.[35] Each research methodology yields unique findings, which contribute to hypothesis validation and practical recommendations.[36] At the conclusion of any research, findings should be analyzed thoroughly to develop actionable solutions that address the specific challenges for which the study was conducted. In developing countries, including Iran, inefficient policies, insufficient waste management budgets, lack of regulations, and inadequate hospital equipment present major obstacles to effective hospital waste management.[37]

A study conducted in Saadat Abad Electricity District (Tehran) used the JHA and failure mode and effects analysis (FMEA) methods to assess and analyze occupational risks associated with electrical accidents. The study identified pertulin explosion and adverse weather conditions (precipitation and wind) as the two highest-ranking risks, with RPN values of 567 and 294, and risk levels of 27 and 49, respectively. To mitigate these hazards, the study recommended using high-quality equipment and materials, adhering to cabling standards, and implementing proper maintenance practices. A laboratory risk assessment conducted using the JHA method found that 64% of risks fell into the high-risk category, 27% were medium-risk, and 9% were low-risk. Recommended control measures included reducing waste generation, implementing structured waste management training programs, and substituting hazardous chemicals with safer alternatives. Additionally, switching from disposable to recyclable laboratory equipment was suggested for mitigating low-risk hazards.[38] A risk assessment of dry drilling machinery operators in North Drilling Company using the JHA method revealed that 7.71% of identified risks were safety-related, followed by sanitary risks (4.13%), ergonomic risks (3.9%), and risks associated with substances and equipment (6.5%). The study categorized 4.84% of risks as low-level, 5.36% as medium-level, and 1.15% as high-level hazards, which required immediate control measures.[39] A study assessing health risks in a petrochemical industry in southern Iran using the localized occupational risk analysis method identified 353 risks. Among these, 48.93% were deemed acceptable, 4.82% were classified as negligible, and 1.7% were medium-risk. The most prevalent hazards were ergonomic risks (22%), while biological risk factors had the lowest frequency. The study emphasized that implementing the localized JHA method allows for effective classification and control of workplace hazards, reducing occupational accidents and associated costs.[40] A study evaluating respiratory risk factors for hospital workers at Shiraz University of Medical Sciences found that N95/FFP2 masks do not provide sufficient protection against certain airborne pollutants. The study recommended using high-protection respirators, such as powered air-purifying respirators (PAPR) or full-face masks with A1B1P3 cartridges, for enhanced protection. When direct measurement of biological pollutants is not feasible, a qualitative risk assessment method (IRSST Institute) can help determine appropriate respiratory protective measures.[41]

A study on occupational safety and risk management in oil rig construction (Reshadat oil field) employed JHA and FMEA methods. The study categorized 62.7% of identified risks as low-level, 31.6% as medium-level, and 5.7% as high-level hazards. After implementing corrective and management strategies, low-risk cases increased by 30.6%, while medium and high-risk cases decreased by 72% and 53%, respectively.[42]

The present study found that the highest-risk factors were dust from soil, methane and CO_2 gases, and uneven surfaces, all of which were classified as unacceptable risks. Accidents, animal bites, and sharp objects were categorized as undesirable risks. The study's findings can be used to develop control measures aimed at reducing risks to acceptable levels.

A study on musculoskeletal disorders among municipal solid waste workers in India found that 70% of participants reported pain in at least one of nine body regions over the past year, while 91.8% experienced pain in the last seven days. The most affected areas were the knees (84.5%), shoulders (74.5%), and lower back (50.9%). The study suggested that long work hours, low job control, and physically demanding tasks contributed to these issues. Implementing a workplace health promotion model could help reduce the high prevalence of musculoskeletal disorders, and a prospective cohort study was recommended for further analysis.[43] An Exposure Risk Assessment of municipal waste collection during the COVID-19 pandemic in Malaysia identified five high-risk activities, including garbage collection, mechanical handling of compactor lorries, and unloading waste at disposal sites. The study found poor personal hygiene practices and inconsistent personal protective equipment (PPE) supply management. It emphasized that until preventive measures are standardized and adopted across the waste collection industry, biological agents will continue to pose significant health risks to workers.[44] A

study on e-waste recycling workers in Thailand found that 64.7% of employees reported nasal irritation, 66.5% experienced coughing or sneezing, and 59.9% had difficulty breathing. Additionally, 58.1% reported skin peeling, and 69.1% experienced muscle aches. The findings highlighted the need for education programs, improved occupational health awareness, and better worker protection policies.[45]

An assessment of health risk awareness among informal e-waste workers in Nigeria revealed that only 43% of workers could identify at least one PPE item required for their job, compared to 70% of butchers in a similar sector. The study found a significant gap in health risk awareness among e-waste workers. Moreover, a positive correlation was observed between workers' knowledge, attitudes, and safe practices, suggesting that improving education and training programs could help reduce hazardous workplace behaviors.[46]

Conclusion

To mitigate workplace risks and prevent associated diseases, waste management authorities should focus on enhancing staff knowledge and awareness of existing hazards. Additionally, periodic health assessments and pre-employment medical examinations should be conducted to ensure job compatibility with employees' physical conditions. Key control measures to reduce risk levels include:

- Providing appropriate PPE such as safety footwear, high-visibility reflective clothing, and respiratory masks with filters, along with regular cartridge replacements to minimize respiratory hazards.
- Implementing periodic medical examinations and annual health monitoring of employees.
- Completely enclosing the aeration area to limit exposure to airborne contaminants.
- Avoiding machinery blind spots to prevent accidents.
- Installing clear safety and hazard warning signs to enhance workplace safety.

By implementing these measures, the overall safety and health conditions of waste management workers can be significantly improved.

Authors' Contribution

Conceptualization: Fariba Jalali, Javid Mohemsaz, Sepehr Akhlaghifard.
Data curation: Fariba Jalali, Javid Mohemsaz, Sepehr Akhlaghifard.
Formal analysis: All authors.
Funding acquisition: Fariba Jalali, Javid Mohemsaz, Sepehr Akhlaghifard.
Investigation: All authors.
Methodology: Fariba Jalali, Javid Mohemsaz, Sepehr Akhlaghifard.
Project administration: All authors.
Resources: All authors.
Software: All authors.
Supervision: Fariba Jalali, Javid Mohemsaz, Sepehr Akhlaghifard.
Validation: All authors.
Visualization: All authors.
Writing–original draft: Sepehr Akhlaghifard, Nahid Ghobadi, Abbas Esmaeili.
Writing–review & editing: All authors.

Competing Interest

The authors declare no conflicts of interest.

Ethical Approval

Not applicable.

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