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An Overview about Occupational Exposure of Municipal Solid Waste workers

Dina Abd El Wahab Fikry¹, Ahmed Refat Abdel Ghafar¹, Reem Abbas Abbas¹, Amira Raafat El Sheikh², Samah Samir Sheta¹

1 Department of Industrial Medicine and Occupational Health, Faculty of Medicine, Zagazig University, Egypt

2 Department of Clinical Pathology, Faculty of Medicine, Zagazig University, Egypt

Email: DAFekry@medicine.zu.edu.eg, dafekry@zu.edu.eg, dinafikry441@gmail.com

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Abstract:Background: Municipal solid waste workers are workers who involved in street sweeping, waste collection, waste processing, rag picking, waste sorters and waste truck drivers. They play an honorable role in preserving health and hygiene in any country. This job requires much effort to be accomplished, known the nature of the work, workplace conditions, plus predictable and unpredictable variables that track their routine. MSWWs collect plastics, paper, cardboard, wires, glass bottles, rubber materials, sharp metals and harmful electronic materials from landfill sites and garbage collection centers. These can be risky for their health as they are exposed to various infectious agents and toxic substances that may cause illness. Unfortunately, the control of the working conditions and enforcement of appropriate hygienic measures are difficult due to the lack of hygienic standards for biohazardous materials present in the air of the workplace. MSWWs should be treated as a vulnerable group that needs special care. Harmful substances in waste products should be reduced by elimination, substitution, collection techniques or actions in working habits. If workers are still exposed this needs to be prevented by using personal protective equipment. In this case, the workers have to be trained in the appropriate use of personal protective equipment

Keywords: Occupational Exposure, Municipal Solid Waste workers

Introduction

Solid Waste' is defined as the material that has fallen out of the economic cycle of manufacture and consumption. It is an unwanted by-product, a material output from economic inefficiency. According to **Environment Protection Agency (EPA)**, municipal solid waste MSW is known as trash or garbage. In other words, various items consumers throw away after they are used, such as food scraps, newspapers, grass clippings, bottles, paints, etc. All pervious items are generated from households, schools, businesses, and hospitals (1)

The issue of municipal solid waste management (MSWM) in Egypt has become a challenging matter. It has diverse ecological, economic, and social effects. Since 2000, Egypt's municipal solid waste has risen by more than 36% due to the population increase (2).

- **Municipal solid waste generation in Egypt:**

Recently, according to the Solid Waste Management Regulatory Authority, Egypt produces approximately 50 - 60 thousand tons of solid waste daily, accounting for 22 million tons per year. Egypt's population, industrialization, and urbanization are increasing dramatically. Also, change in consumption trends has caused the generation of diversified solid waste representing mainly perceptible environmental problem among many areas especially in urban areas (3).

The MSW generation rates vary greatly between rural and urban areas. About 45% of the generated MSW comes from Greater Cairo (Cairo, Giza, and Qalioubiya governorates) and Alexandria, with a total population of 30.7 million generating 32,570 tons/day and with a collection efficiency between 50 and 70%. These regions are followed by the Delta region consisting of the seven governorates of Beheira, Kafr El-Sheikh, Gharbia, Monufia, Sharqia, Dakahlia, and Damietta. This area has a total population of 36.4 million, which generates 30% of the total MSW and the remaining 25% generated by the other governorates (4).

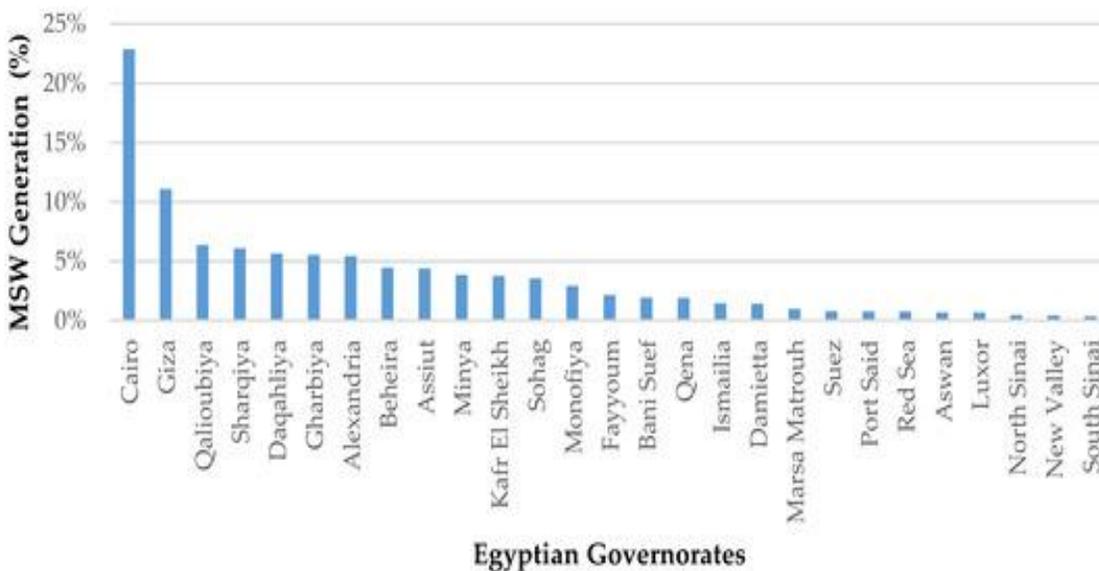


Figure 1: MSW generation distribution in Egypt (4)

Occupational Exposure of Municipal Solid Waste workers

Municipal solid waste workers are workers who involved in street sweeping, waste collection, waste processing, rag picking, waste sorters and waste truck drivers. They play an honorable role in preserving health and hygiene in any country. This job requires much effort to be accomplished, known the nature of the work, workplace conditions, plus predictable and unpredictable variables that track their routine (5).

MSW workers collect plastics, paper, cardboard, wires, glass bottles, rubber materials, sharp metals and harmful electronic materials from landfill sites and garbage collection centers. These can be risky for their health as they are exposed to various infectious agents and toxic substances that may cause illness (6).

MSW workers are exposed to physical, chemical, biological, ergonomic hazards in addition to multiple risk factors and every day they face job related dangers and accident risks related to the content of the materials they handled, emissions from those materials, and the equipment being used (7).

Waste workers suffered from different diseases and faced many health problems. Runny nose, sneezing and coughing, respiratory symptoms, frequent headache, eye infections, musculoskeletal symptoms like tiredness, backache, body pain were common symptoms they face. Similarly, skin rashes, vomiting and diarrhea and

carcinogenic effects as well as injuries caused by work-related accidents were also common problems that waste pickers face (8).

Unfortunately, the control of the working conditions and enforcement of appropriate hygienic measures are difficult due to the lack of hygienic standards for biohazardous materials present in the air of the workplace (9). In addition, in many developing countries the authorities could not give their attention to the waste workers due to various reasons such as lack of proper planning, weak waste management system, lack of awareness and unequal resource distribution. Furthermore, waste workers are often at the bottom of the social ladder and cannot make heard their voice to the authority (6).

In Egypt, the Egyptian waste collectors are dealing manually with mixed hazardous wastes with substantially increased occupational health impacts (10). The health impact and morbidity data about occupational exposure to solid waste among Egyptian solid waste workers have been studied in number of papers. Respiratory, gastrointestinal, and skin infections found to be common among Egyptian solid waste workers. (11). In addition, workers' exposure to occupational injuries as cut wounds and puncture wounds were reported in other papers (11).

Work related health and safety hazards among municipal solid waste workers (MSWWs):

Work-related safety and health hazards are major public health concerns worldwide. The occurrence of workplace hazards, occupational diseases, and deaths contribute significantly to the increase in the global burden of non-communicable diseases (NCDs), The Municipal Solid Waste (MSW) workers experience occupational stressors throughout the process of waste management that affects their well-being and results in high rates of occupational health problems (12).

Table (A): Classification of the main occupational hazards to which waste workers are exposed according to their nature (13; 14):

Physical hazards	Chemical hazards	Biological hazards	Ergonomic hazards	Psychosocial hazards	Accident hazards
<ul style="list-style-type: none"> ▪ Excessive noise. ▪ Extreme heat and cold weather. ▪ Solar radiation. 	<ul style="list-style-type: none"> ▪ Dusts. ▪ Gases ▪ Vapors. ▪ Chemicals in general. 	<ul style="list-style-type: none"> ▪ Viruses. ▪ Bacteria. ▪ Fungi. ▪ Parasites. 	<ul style="list-style-type: none"> ▪ Intense and repetitive physical exertion. ▪ Inadequate posture. ▪ Long working hours. 	<ul style="list-style-type: none"> ▪ lack of training. ▪ Disrespect of society. ▪ Job insecurity ▪ Violence from public ▪ Family problems 	<ul style="list-style-type: none"> ▪ Cuts and perforation ▪ Slips, falls. ▪ Animal attacks. ▪ Rundown, press, amputation

Common physical hazards:

Outdoor workers are exposed to many types of hazards that depend on their type of work, geographic region, season, and duration of time they are outside. Physical hazards to outdoor workers may include extreme heat, extreme cold, noise, and sun exposure (15).

- **Extreme heat and cold:**

Extreme heat can cause heat stroke, heat cramps, heat exhaustion, heat rash, and other problems. Extreme cold can cause hypothermia, frostbite, and other problems according to National Institute for Occupational Safety & Health (NIOSH)(15).

A study observed that municipal solid management operations such as street sweeping, landfilling activities, and door to door waste collection are performed in such hot environments, often in unshaded areas, most waste workers complained of headaches, sunburn, heat stress, excessive sweating, dehydration, and difficulties in concentration in assigned tasks. Notably difficulties in concentration may increase the risk of being run over not only by waste collection vehicles but also by other traffic especially during the day when the traffic volume is high (16).

- **Noise:**

The major sources of noise were waste collection vehicles' running engines, other traffic and landfilling vehicles., Constituents of municipal solid waste such as glass and metal tins also contributed to the occupational noise particularly during emptying of metal bins on the metal floor of waste collection vehicles. High working speed with regard to offloading of waste bins tended to produce a monotonous noise **(16)**. repeated exposures to loud noise can lead to permanent, incurable hearing loss or tinnitus according to National Institute for Occupational Safety & Health (NIOSH) **(15)**.

✓ **Chemical hazards:**

The major toxic waste streams in municipal solid waste included hair sprays, shampoos, expired medicines, pesticides and e-waste, shoe and floor polish, carpet and furniture cleaning agents, motor vehicle brake fluid, battery acid, and discarded pesticide containers in household waste streams which could be a source of arsenic exposures for waste workers. Toxic waste (although available in small quantities (1%)) unavoidably renders the entire municipal solid waste potentially toxic and can lead to various occupational health risks for waste collectors through inhalation, ingestion, and dermal exposure pathways **(16)**. Pesticide residues such as organophosphates could affect the central nervous system through inhibition of the choline esterase enzyme **(1)**.

Ncube et al. (16) found the major e-waste components were fluorescent and nonfluorescent bulbs, circuit boards, lead and acid car batteries which can be source of lead (Pb) and mercury (Mg), Similarly, inks for printers and rechargeable batteries can be a source of cadmium (Cd), Also, monitors and keyboards in municipal solid waste streams are a cause of concern since they can be primary sources of polyvinyl chlorides (PVC) which may emit harmful gaseous substances such as hydrogen chloride gas.

Also, Inhalation of toxic emissions like carbon monoxide and carbon diode from traffic exhausts pipes may further exacerbate decreased concentration **(16)**.

✓ **Biological hazards:**

Waste workers are susceptible to several biological damages that lead to the acquisition of several infections **(13)**. They are spending many hours at the dump site where there are lots of flies and mosquitoes **(17)**. Also, there are several microbial species that may be released from household waste.

as it consists of many different components, including 31% vegetable waste, 10% animal waste, 6.6% diapers, 3.3%-yard waste, and 0.93% vacuum cleaner bags **(18)**.

• **Parasitic infection among MSWWs:**

Waste can include the eggs of parasitic worms (helminths e.g. *Ascaris lumbricoides*) and the cysts of parasites which can cause a gastrointestinal infection such as amoebiasis (*Entamoeba histolytica*), and giardiasis (*Giardia lamblia*) **(19)**.

In another study, **Santos (20)** identified the prevalence of soil transmitted helminthiasis above 35% of solid waste workers. with a prevalence of 25.15% for ascariasis, and 9.82% for hookworm.

• **Viral infection among MSWWs:**

Solid waste handlers are usually at significant risk for multiple injuries and illnesses, including blood borne viral infections such as HIV and hepatitis, due to waste exposure to contaminated needles or sharp items that may contribute to the spread of the disease **(21)**. This is especially the case if the medical waste is present in normal domestic waste **(19)**.

Hepatitis B virus (HBV) infection is a serious public health problem that attacks the liver and can cause both acute and chronic disease. Transmission routes of the hepatitis B virus include parenteral or mucosal exposure to infectious blood or other body fluids, unprotected sexual intercourse and mother-to-child transmission **(22)**.

Some professions are at an increased risk for hepatitis B virus infection including health care workers. and some neglected professions, such as recyclable waste collectors, can also be exposed to this blood-borne pathogen through occupational injuries **(23)**.

The high prevalence of viral hepatitis B and C in Egypt has elevated the concern regarding the potential for disease transmission among municipal solid waste workers (MSWWs) from solid waste stream sources. Such

transmission has never been epidemiologically demonstrated, throughout the world, little is known on the magnitude of infection spread as a result of waste handling (24).

Many studies conducted on MSWWs in Egypt to reveal the prevalence of blood borne viral infections. **El-Wahab et al. (24)** revealed that the overall seroprevalences of blood borne viral infections were: hepatitis B; 36.1%; hepatitis C; 8.4%; and HIV; 0.0%. while in 2018 **Abd El-Wahab and Eassa (9)** demonstrated that the overall seroprevalence of active HBV infection was 1.5%. in total, 3.8% of the workers received the compulsory HBV vaccine during their infancy, meaning approximately 96.2% of the participants were at risk for HBV infection. Moreover, **Elkhateeb et al. (25)** performed another study in El-Minia city, Egypt and reported that 21.6 % of the municipal solid waste collectors were anti-HCV antibodies sero-positive.

- **Bacterial infection among MSWWs:**

Biowastes, especially food scraps contain huge numbers of bacteria. Most of these bacteria are saprophytic bacteria, i.e. they feed and grow on decaying organic matter. However, some of these species particularly those present in animal waste, may be pathogens, and they can cause serious infections, such as brucellosis, salmonellosis and shigellosis (19).

All gram-negative bacteria in the waste contain endotoxins, these endotoxins are pulmonary immunotoxicants, they can cause acute systemic symptoms (fever, shivering, and joint pain) and respiratory symptoms (dry cough, shortness of breath), chronic effects of endotoxin exposure are (COPD, chronic obstructive pulmonary disease) (26). Additionally, endotoxin may exert adjuvant effects in the subject's reactions to allergens since they may synergistically enhance the release of allergic mediators and increase the production of antibodies (19).

Gram-positive bacteria, such as Actinobacteria, Bacillus, and Clostridium genera, produce spores which are difficult to destroy (resistant to heat, cold, and sunlight). In particular, "thermophilic Actinobacteria" can promote the development of extrinsic allergic alveolitis. Bacillus and Clostridium bacteria may be considered as pathogens, since, in some circumstances they can be the source of the anthrax (Bacillus anthracis), botulism (toxin of Clostridium botulinum), or tetanus (Clostridium tetani) (19). **Madsen et al. (18)** demonstrated in their study that the MSWWs were exposed to 38 bacterial species including skin-related bacteria and bacteria expected to origin from the waste.

- **Fungal infection among MSWWs:**

Bioaerosols containing fungi, bacteria, mycotoxins, endotoxins and glucans, MSWWs in landfill sites may potentially be exposed to high levels of bioaerosols during the dumping of waste, Fungi, such as moulds and yeasts, may trigger extrinsic allergic alveolitis, asthma and hypersensitivity, or organic dust toxic syndrome (ODTS) a property they share with bacteria. The acute symptoms of allergic alveolitis appear 4 to 6 hours after exposure to the microorganisms. ODTS is an acute condition; it is the body's response to exposure to toxic levels of a hazard, but in general, ODTS does not lead to long term health effects and usually disappears on the next day after the exposure (19).

Madsen et al. (18) concluded in their study in which they collect samples from airborne microorganisms, the truck cab, on the workers' clothes, and outdoors, that fungal and bacterial species, found in high concentrations in personal samples, were also found in truck cabs, but in lower concentrations indicating that fungi and bacteria are transported by the workers into the truck cab. Penicillium species dominated the fungal exposure, and workers were exposed to 11 different Penicillium species and 12 other fungal species.

- **Allergy among MSWWs:**

Contact with the organic components of animal or vegetable waste may have impacts on workers through allergenic routes. The allergic type I responses are generated by immunological sensitisation towards a specific agent, and they lead to the production of a specific immunoglobulin E response. Some typical IgE-mediated allergies include asthma, allergic rhinitis and dermatitis caused by a skin contact with the allergen (19).

Wassiem et al. (27) found that the level of high-sensitivity C-reactive protein (hsCRP) as a biomarker of inflammation was elevated in 12.9% of MSWWs while total serum immunoglobulin E was obviously high among most of them (79.2%).

Amadi et al. (28) revealed in their study that 32.2% of the solid waste workers reported that they have even been hospitalized due to work-related hazards, with allergies (23.2%) and rash/other skin diseases (22.1%) identified as the most experienced type of illness.

✓ **Ergonomic hazards:**

Ergonomics mean fitting a job to a person **(19)**. Ergonomichazard is another occupational health risk affecting solid waste workers, which comprises threat to the musculoskeletal system **(13)**.

Musculoskeletal disorders (MSDs) are an important health problem in both developed and developing countries, with substantial impact on the quality of life as well as a substantial economic burden in compensation costs, lost wages, and productivity. MSDs contribute to absenteeism, increased work restriction, transfer to other jobs, or disability more than any other group of diseases with a considerable economic effect on the individual, the organization, and the society as a whole. Moreover, MSDs are the most expensive form of work disability **(29)**.

The activity of waste collection leads to inadequate posture and repetitive physical exertion as lifting, lowering, extended sitting standing, bending, pushing, and pulling of collection boxes, bins, bags, and carts. The weight of such containers is variable depending on the type of waste, the container features, the collection frequency, and other variable factors. Such characteristics impact on the workers' exposure to the risk of manual material handling of waste containers and on the risk of developing work-related musculoskeletal disorders **(13)**

✓ **Psychosocial hazards:**

In addition to health risks and morbidities, the MSWworkers face job insecurity, unsafe working conditions, poor health and poor income, as a result, their quality of life is affected leading to job losses, economic implications arising out of occupational health problems, and increased economic burden **(30)**.

MSW workers may also be subjected to social stigma and bullying or conflict while competing for waste resources. MSW workers often live in isolation as a result of stigma and may experience low self-esteem, which may negatively affect their psychological wellbeing. They also face social discrimination and abuse from certain elements of society, which may lead to social problems **(6)**.

✓ **Accidents hazards:**

According to the ILO estimates, every year over 2.3 million women and men die at work from an occupational injury or disease. Over 350,000 deaths are due to fatal accidents and almost 2 million deaths are due to fatal work-related diseases. In addition, over 313 million workers are involved in non-fatal occupational accidents causing serious injuries and absences from work. The ILO also estimates that 160 million cases of non-fatal work-related diseases occur annually. The incidence of injuries is increasing globally and in developed countries, the injuries are not only associated with significant morbiditybut are also associated with work absenteeism **(according to NIOSH) (15)**.

Occupational injuries may occur in the entire continuum of the waste management cycle **(31)**.Accidental injuries such as puncture wounds, lacerations, burns, dog and rat bites, sprains, abrasions, fractures, eye injuries, and sharp backaches are significantly more common because of exposure to sharp waste objects or falling heavy containers. Some waste handlers climb and sit on top of the truck full of garbage, thus exposing themselves to falling from the moving truck **(17)**.

A study carried out at Alexandria it was noticed that more than three quarters (76%) of the waste collectors experienced work-related accidents and, around half (49%) of the collectors were previously hospitalized because of work related hazards**(11)**.

A study in Latin America revealed that the majority of waste pickers (68.70%) reported accidents and most of them (89.69%) were related to sharp objects **(32)**. Also, **Ramitha et al. (12)** reported thatcuts with sharps (26.9%) were the second most reported occupation-related injury with 95.5% of the garbage collectors

having experienced cuts/injuries in the past year. Additionally, **Amer and Hussein (14)** illustrated in their study on MSWWs at Menoufia Governorate, Egypt that the accidental hazards were mentioned as falling from truck by (45.0%) of studied waste workers.

In Minia city, Egypt study conducted and revealed that 60.7% of studied workers were exposed to occupational injuries. Also, another study revealed that (61.5%) of the respondents had experienced work-related injuries/accidents within the last 12 months, with cuts (30.0%) puncture wounds (20.5%) and road accidents (20.2%) as the most experienced hazards **(28)**.

Examples of Body Systems Affection among MSWWs:

Musculoskeletal disorders (MSDs)

The effect of waste collection method on the musculoskeletal disorders (MSDs) has been a challenge. Efforts had been intensified to reduce MSDs of MSW workers through various ergonomic studies **(33)**.

A study of health problems among MSWWs in Sohag city, Egypt found that more than half of the workers complain of musculoskeletal disorders (58%) **(10)**. In another study conducted in Alex, Egypt found that musculoskeletal pain was stated by about three quarters (74.5%) of the MSWWs mainly neck and low back pain (54.3% and 44.3 % respectively) **(11)**.

Respiratory system affection of MSWWs:

Inhalation of bioaerosols generated by the decomposition of organic waste increased risk of respiratory system affection. This process can lead to the formation of various biological agents including bacteria, fungi, and volatile compounds such as endotoxins, β (1-3)-glucans, and mycotoxins that can provoke an inflammatory response at the level of the airways mucosa, probably due to a complex interaction among microorganisms or cell wall components of these microorganisms and the host immune system **(34)**.

When assessing the respiratory health risk in solid waste disposal workers, it is also important to take into account the physical effort and muscle work that these activities entail, during lifting and manhandling of the various containers. This induces a ventilation response consisting of an increased flow volume and respiratory frequency that will increase the amount of bioaerosol inhaled, including not only airborne organic compounds, but also dust particles and vehicle exhaust fumes and gases. These factors have been reported to be responsible for a higher incidence of respiratory diseases in this worker category, namely, influenza-like disorders (rhinitis, conjunctivitis, cough, headache) **(6)**.

Gastrointestinal system affection of MSWWs:

Gastrointestinal disorders were found in 24% of studied waste workers in Sohag city, Egypt **(10)**. Additionally, **Madian and Abd El-Wahed (11)** found that the most frequent complaints encountered among waste collectors were GIT complaints that stated by whole collectors.

Kasemy et al. (35) also found in their study that GIT symptoms as vomiting, diarrhea, dysentery, and dyspepsia were significantly higher among studied MSWWs (9.5%, 16%, 15.6%, and 24.7%, respectively) than controls (3.3%, 2.9%, 2.2%, and 9.8%, respectively). Also, **Amer and Hussein (14)** study results on MSWWs illustrate that the common frequent complaint reported among them were gastrointestinal problems (82.2%) and 60.9% of the sample complained from worm infestation.

Eye affection of MSWWs:

Shams El-Din et al. (10). found that about (18%) of studied waste workers complain of eye disorders. Furthermore, **Madian and Abd El-Wahed (11)** reported that (95.7%) of the waste collectors had eye problems mainly redness as reported by less than three quarters (73.3%) of the collectors.

Amer and Hussein (14) study result on municipal solid waste workers illustrated that 78.6% of them had eye disease especially redness as reported by 66.4% of them.

Skin affection of MSWWs:

Dermatitis is an important health problem reported in many studies which can be from fungal origin as well as an immune reaction against antigens. **(13)**

Shams El-Din et al. (10) revealed that skin disorders were reported by (16.8%) of studied MSW workers, Also, **Madian and Abd El-Wahed (11)** demonstrated that waste collectors who complained of skin problems

constituted (83%) including itching and nail infection (57.7 % & 46.2% respectively) and scabies in (14.1%) of them. **Amer and Hussein (14)** also reported that 81.4% of the studied municipal solid waste workers had skin problems especially itching stated 43.9% of solid waste collectors.

References:

1. EPA (2022): Human Health Issues Related to Pesticides, U.S. Environmental Protection Agency. Available at: <https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/human-health-issues-related-pesticides>. Accessed Dec, 2022.
2. Ibrahim M. and Mohamed N. (2016): Towards sustainable management of solid waste in Egypt. *Procedia Environmental Sciences*, 34(1), pp.336-347.
3. El Masry R. (2019). Good governance and integration for sustainable municipal solid waste management: a case study of Egypt. pdf, Available at: <https://fount.aucegypt.edu/cgi/viewcontent.cgi?article=1804&context=etds>.
4. Hemidat S., Achouri O., El Fels L., et al. (2022): Solid waste management in the context of a circular economy in the MENA region. *Sustainability*, 14(1), p.480.
5. Ravindra K., Kaur K. and Mor S. (2016): Occupational exposure to the municipal solid waste workers in Chandigarh, India. *Waste Management & Research*, 34(11), pp.1192-1195.
6. Baral Y. (2018): Waste Workers and Occupational Health Risks. *International Journal of Occupational Safety and Health*, 8(2), pp.1-3.
7. Marahatta S., Katuwl D., Adhikari S., et al. (2017): Knowledge on occupational health hazard and safety practices among the municipal solid waste handler. *Journal of Manmohan Memorial Institute of Health Sciences*, 3(1), pp.56-72.
8. Mol M, Pereira A, Greco D, et al. (2017): Assessment of work-related accidents associated with waste handling in Belo Horizonte (Brazil). *Waste Management & Research*, 35(10), 1084-1092.
9. Eassa S., El-Wahab E., Lotfi S., et al. (2016): Risk Factors associated with parasitic infection among municipality solid-waste workers in an Egyptian community. *Journal of Parasitology*, 102(2), pp.214-221.
10. Shams El-Din A., Mohammed A. and Abd El Gaber M. (2017): Study of Health Problems among Municipal Waste Collectors in Sohag City, Egypt. *N Y Sci J*;10(4), pp.75-79.
11. Madian A. and Abd El-Wahed A. (2018): Adverse Health Effects among Solid Waste Collectors in Alexandria Governorate, *International Journal Of Occupational Health and Public Health Nursing*, 5(2), pp.23-48.
12. Ramitha K., Ankitha T., Alankrutha R., et al., (2021). A cross-sectional study on occupational health and safety of municipal solid waste workers in Telangana, India. *Indian Journal of Occupational and Environmental Medicine*, 25(3), pp.169-170.
13. Pereira-de-Paiva M., da Conceição Calassa-Albuquerque M., Latham E., et al., (2017): Occupational hazards of Brazilian solid waste workers: a systematic literature review. *Rev. bras. med. trab*, 15(4), pp.364-371.
14. Amr A., and Hussein A. (2021): Occupational Health Hazards and the Use of Safety Protective Measures among Municipal Solid Waste Collectors. *Egyptian Journal of Health Care*, 12(2), 830-853.
15. CDC (2015): Hazards to Outdoor Workers, NIOSH available at: <https://www.cdc.gov/niosh/topics/outdoor/default.html>. Retrieved April 2022
16. Ncube F., Ncube E. and Vuyi K. (2017): Bioaerosols, noise, and ultraviolet radiation exposures for municipal solid waste handlers. *Journal of environmental and public health*, 17(2) pp.1-7.
17. Tshivhase S., Mashau N., Ngobeni T., et al., (2022): Occupational health and safety hazards among solid waste handlers at a selected municipality South Africa. *Health SA Gesondheid (Online)*, 27, pp.1-8.
18. Madsen A., Alwan T., Ørberg A., et al. (2016): Waste workers' exposure to airborne fungal and bacterial species in the truck cab and during waste collection. *Annals of Occupational Hygiene*, 60(6), pp.651-668.
19. OSHA (2020): Personal Protective Equipment, Hazards and Solutions PPE Training Materials and Training Occupational Safety and Health Administration, available at: https://www.osha.gov/SLTC/personalprotectiveequipment/hazards_solutions.html
20. Santos C. (2016): Geohelminthiasis in public waste workers in the city of Parnaíba-Piauí: prevalence and risk factors [master's thesis]. Rio de Janeiro: Escola Nacional de Saúde Pública Sergio Arouca. pp.1-3.
21. Wanjari M. and Mendhe D. (2021): Prevalence Rate of Hepatitis C Among the Solid Waste Handler in Wardha City. *Cureus*, 13(11), pp.1-2.
22. WHO (2018): editor Declaration of Astana. Global conference on primary health care; Kazakhstan: World Health Organization, Available at: <https://www.who.int/docs/default-source/primary-health/declaration/gcphc-declaration.pdf>. retrieved December, 2021.
23. Marinho T., Lopes C., Teles S., et al. (2014): Epidemiology of hepatitis B virus infection among recyclable waste collectors in central Brazil. *Revista da Sociedade Brasileira de Medicina Tropical*, 47(1), pp.18-23.
24. El-Wahab E., Eassa S., Lotfi S., et al. (2015): Seroprevalence, immunostatus and factors associated with blood borne viral infections among Egyptian municipal solid waste workers. *J VirolAntivir Res*, 4(4), pp.2-7.

25. Elkhateeb A., Abotakya F., Refat T., Hamdy, et al. (2019): Screening of Cases of Chronic hepatitis C viral infection among municipal solid waste collectors in Minia city, Egypt. *Minia Journal of Medical Research*, 30(1), pp.27-34.
26. Lucas R., Hadizamani Y., Gonzales J., et al. (2020): Impact of bacterial toxins in the lungs. *Toxins*, 12(4), pp.223-224.
27. Wassiem A., Zaki G., Charl F., et al. (2021): Biochemical changes among municipal solid waste sorting workers: implications for personal protective equipment availability and use. *International Journal of Occupational Safety and Ergonomics*, 27(4), pp. 1028-1038.
28. Amadi S., Clement E., Pelebo E., et al. (2023): Practices of Occupational Health and Safety and Experience of Occupational Hazards among Solid Waste Managers in Port Harcourt Metropolis of Rivers State. *medRxiv*, pp.2023-2024.
29. Reddy E. and Yasobant S. (2015): Musculoskeletal disorders among municipal solid waste workers in India: A cross-sectional risk assessment. *Journal of family medicine and primary care*, 4(4), p.519.
30. Thakur P., Ganguly R. and Dhulia A. (2018): Occupational Health Hazard Exposure among municipal solid waste workers in Himachal Pradesh, India. *Waste Management*, 78, pp.483-489.
31. Byonanebye D., Nankya J., Arinaitwe I., et al. (2022): Occupational Injuries and use of Personal Protective Equipment among Casual Municipal Solid Waste Workers in the Informal Sector in Kampala: A Cross-Sectional Study.: Occupational injuries in informal waste workers. *Student's Journal of Health Research Africa*, 3(3), pp.10-10.
32. Cruvinel V, Marques C, Cardoso V, et al. (2019): Health conditions and occupational risks in a novel group: waste pickers in the largest open garbage dump in Latin America. *BMC public health*, 19(1), p.1-15.
33. Yussouf A., Adedeji K. and Ismaila S. (2017): Ergonomic Analysis of Worker Postures in Waste Collection Job. *International Journal of Management and Sustainability*, 6(3), pp.47-53.
34. Vimercati L., Baldassarre A., Gatti M., et al. (2016): Respiratory health in waste collection and disposal workers. *International journal of environmental research and public health*, 13(7), pp.631-639.
35. Kasemy Z, Rohlman D. and Abdel Latif A. (2021): Health disorders among Egyptian municipal solid waste workers and assessment of their knowledge, attitude, and practice towards the hazardous exposure. *Environmental Science and Pollution Research*, 28(24), pp. 30993-31002.