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Journal of Natural and Applied Sciences Pakistan

Journal homepage: http://jnasp.kinnaird.edu.pk/

REVIEW ON OCCUPATIONAL HEALTH AND SAFETY ISSUES IN FERTILIZER INDUSTRY

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Abstract

Fertilizers are the compounds that provide nutrients to plants to increase and maintain maximum crop yields. The most common fertilizers in mass production are urea and ammonium nitrate, both synthesized with ammonia using a process based on the Haber-Bosch method discovered in 1909. As the world's population continues to grow and living standards rise, the need for cheap and reliable supply of these nutrients needed for crop growth has become more important. According to the estimates, half of the current food supply depends on nitrogen in ammonia-based fertilizers. Although, the fertilizers use in agriculture sector is inevitable for achieving high yield crop production to meet increasing food demand, yet the production of fertilizers and by-products pose health and safety challenges due to the risks associated with its production process. During fertilizers manufacturing and packaging processes, workers may encounter hazardous chemical emissions such as toluene, benzene, xylene, and carbon monoxide. The fertilizer industry may also involve physical hazards or chemical hazards due to fumes/particles produced from granules, pellets etc. Noise has become a major problem in industrial sectors. Several studies show that those working in the fertilizer industries are expected to have high levels of noise exposure. Poor light is harmful to health and can cause eye fatigue, eye pain and headaches. That is why good health and safety practices must be a top priority for any industry. In order to minimize these hazards, several measures need to be taken including continuous risk assessment of the fertilizer industry to identify potential hazards, proper training of workers, and efficient and effective use of PPEs and periodic medical examination for early detection and management of health hazards.

Keywords
Occupational Health, Fertilizer, Fertilizer Hazards, Injuries, Fertilizer Contamination

1. Introduction

Fertilizers are the compounds that provide nutrients to plants to increase and maintain maximum crop yields (Chien *et al.,* 2009). They are classified as organic and inorganic fertilizers. Commercial organic fertilizers are by-products of the livestock, fish, food and other processing industries whereas inorganic fertilizers are mainly composed of nitrogen (N), phosphorus (P) and potassium (K) (Gaske & Smith, 2007) (Savci, 2012).

The most common fertilizers in mass production are urea and ammonium nitrate, both synthesized with ammonia using a process based on the Haber-Bosch method discovered in 1909. The first ammonia synthesis plant that led to the production of synthetic fixed nitrogen began in 1913 and today accounts for more than 85% of the fertilizer that feeds about 50% of the world's population. As the world's population continues to grow and living standards rise, the need for cheap and reliable supply of these nutrients needed for crop growth have become more important (Eames & Brightling, n.d.) (Heffer & Prud' homme, 2013) (Brightling, 2018).

According to the estimates of researchers, half of the current food supply depends on nitrogen in ammonia-based fertilizers (Erisman *et al.,* 2008). Until 2050, the world's population will increase by 30%, the demand for agricultural products by 70% and the demand for meat by 200% (Alexandratos, 2009). It relates to fundamental changes in food demand due to population growth, dietary changes in many countries and regions, and increasing use of food crops for fuel production. The environmental, health and climate aspects of fertilizers in different growth scenarios are discussed elsewhere (Winiwarter *et al.,* 2013) (Van Grinsven *et al.,* 2014).

Although, the fertilizers use in agriculture sector is inevitable for achieving high yield crop production to meet increasing food demand, yet the production of fertilizers and by-products pose challenges in terms of process safety due to the risks associated with its production process.

2. Aim

The aim of this review is to focus on the potential occupational risks associated with fertilizer industry, identify gaps in term of OHS and develop recommendations based upon review and analysis of literature.

3. Occupational Health & Safety Hazards

During fertilizers manufacturing and packaging processes, workers may encounter emissions of toluene, benzene, xylene, and carbon monoxide, as well as noise and light. Occupational hazards include exposure to mixtures containing high content of active ingredients and exposure to carriers/ fillers and additives. The fertilizer industry may also involve physical hazards or chemical hazards due to fumes/particles produced from granules, pellets and emulsifiable concentrates (NOHSC, 1994). Noise has become a major problem in industrial sectors. Harmful health effects of noise include anxiety, lack of sleep and hearing, deafness, or disability. Several studies show that those working in the

fertilizer industries are expected to have high levels of noise exposure (NIOSH, 1998) (Gomes *et al.*, 2002) (NIOSH, 2001). Poor light is harmful to health and can cause eye fatigue, eye pain and headaches (ES, 1991). That is why good health and safety practices must be a top priority for any industry. Industry safety concerns include structural safety, fire safety, health safety, emergencies and accident prevention (El-Said, 2008).

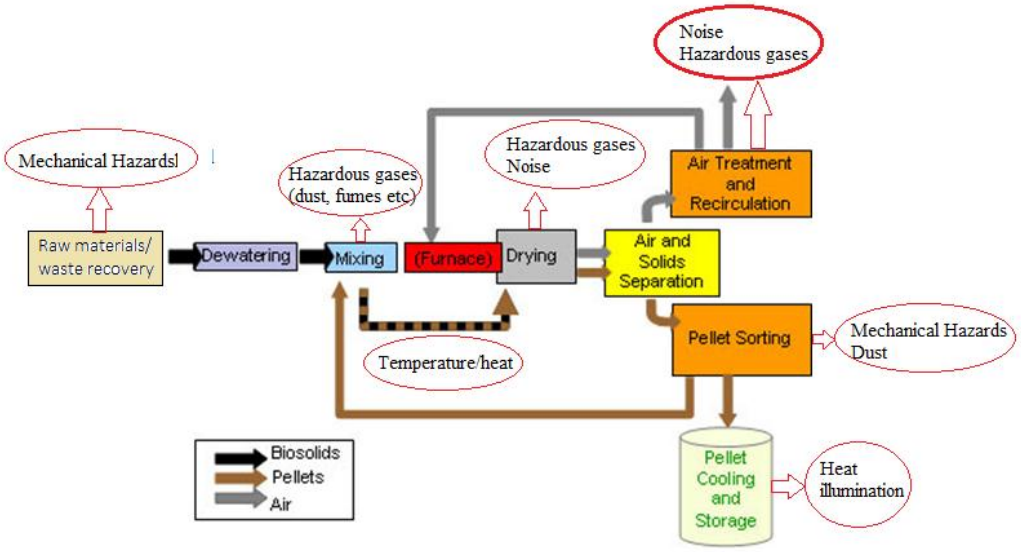

Figure 1: Potential Hazards From Different Fertilizer Manufacturing Processes

3.1 Respiratory Problems

The fertilizer industry workers, work in the presence of hazardous gases that may cause severe respiratory problems if proper protective measures are not taken. The prevalence of work-related respiratory problems such as nasal congestion, cough, expectoration , dyspnea , shortness of breath, wheezing and asthmatic bronchitis have been reported among the workers of phosphate fertilizer industry in Egypt (Zayed *et al.*, 2020). Similar respiratory problems were reported with rhinitis dominating in the factory workers (Shaheen *et al.*, 2015). However, Gorman reported less prevalence of respiratory diseases in the factory workers as compared to the aforementioned studies. This difference can be explained by the different workplace conditions and the short exposure time (Gorman, n.d.).

A major difference is depicted in the prevalence of respiratory problems among the workers of phosphate fertilizer industry and nitrogen fertilizer industry. The phosphate fertilizer workers comparatively showed less respiratory problems than the workers of nitrogen fertilizers (Aly & Mohammad, 2018). The difference in

these results can be attributed to the difference in the tools used to collect data in each study and the safety measures used in each industry e.g., two-plant ventilation systems. Moreover, more respiratory irritants are released during the manufacturing of nitrogenous fertilizers (such as ammonia).

3.2 Biological Hazards

The main activity of the fertilizer industry involves dealing with toxic and hazardous substances. The mishandling of these chemicals or any fire accident due to them can result in severe burns and injury. Montano reported in his study that among all the workers exposed to biological hazards In fertilizer industry, half of them experienced skin problems (Montano, 2014). However, the study of Aly and Mohammad showed different results in which less than one quarter of the workers had skin complaints (Aly & Mohammad, 2018).

3.3 Mechanical Hazards

The injuries due to fall and slip are the most frequent occupational injuries. In a study about occupational hazards in fertilizer industries of Egypt found human fall to be the most common cause of occupational accidents followed by hazardous chemicals and falling objects (El-Wafa, 2017). These results are supported and explicitly stated that more than two-thirds of workers had injuries related to mechanical hazards and more than a quarter had injuries due to chemicals (Khan *et al.,* 2006). However, Aly and Mohammad reported results contradicting to aforementioned studies that stated that one third of the injuries are due to mechanical hazards whereas more than two third are from the chemical hazards. This difference in the result indicates non-compliance with protective clothing (Aly & Mohammad, 2018).

3.4 Noise and Illumination

Noise has become a major problem in industrial sectors. Several studies show that those working in the fertilizer industries are expected to have high levels of noise exposure (NIOSH, 1998) (Gomes *et al.,* 2002) (NIOSH, 2001). Poor light is harmful to health and can cause eye fatigue, eye pain and headaches (ES, 1991).

El-Said KF reported that light in the fertilizer packaging industry was 321 lux that is well below the standard level of OSHA of 500 lux (El-Said, 2008). This can have serious health effects such as glare, cataracts and eye strain. This is in accordance with the results of other studies (Juslen *et al.*, 2006). The noise level was also higher than the OSHA standard level of 85 dB, which can lead to serious health problems (El-Said, 2008).

3.5 Radiological Hazard

Some nutrients such as phosphorus do not occur free in nature and form complexes such as phosphorites. Different phosphate fertilizers such as single super phosphate (SSP) are produced utilizing these phosphorites as a raw material. Phosphate form complex with uranium therefore phosphorite (PR) contains uranium radioactive and its progeny (Jasinki, 2003). This can pose radioactive hazard to the workers working in phosphate fertilizer industry if

exposed for a longer duration of time. The study conducted by Sabiha et al. showed that the amount of radon measured in phosphate mines is more than permissible limit. Phosphate radioactive contamination is a major public health risk associated with phosphate and SSP fertilizers (Tufail & Asghar, 2010). However, these results are not in line with the study conducted in Croatia that depict negligible health effects due to the annual exposure of ^{236}Ra in the area surrounding fertilizer industry (Bituh *et al.*, 2009)

4. Summary

Following table shows the summary of potential hazards from fertilizer industry, its likely consequences and actions required to mitigate these hazards.

Hazard Category And Hazard	Consequences	Required Actions
Hazardous substances Dust produced during dry mixing process and during loading of dry ingredients into hopper. Hazardous gases like ammonia, carbon dioxide from ammonia plant during pre-neutralizing process, flash separator and decomposing unit.	Dust produced during dry mixing process causes toxic particulate matters to enter into the respiratory system of those working around it. Exposure to the toxic gases like ammonia and carbon dioxide above permissible limit is very dangerous. They bind with the blood and causes blood, skin and lung cancer. Ammonia is strong irritant to respiratory system, it not only impact lungs but also cause infection of eyes and skin thus causing person to become fatal. Being corrosive in nature, ammonia can cause burning in nose, trachea and throat.	Provide full face respirators to the workers involved in work near this process. Trainings must be provided to workers related to hazards linked with hazard of dust. Dust and ammonia scrubbers must be installed in the workplace to capture dust particles. Provide instructions to workers to take bath after leaving workplace. Place a sign board of hazardous fumes at workplace to remind them regarding wearing of masks
Fire Any flammable gas or fumes released from drying unit of NPK plant upon exposure to igniting substance produces explosion.	Exposure for longer time period causes issues like damage to central nervous system by reducing the neuron activity. Inhaling toxic fumes causes dizziness, feeling of euphoria and confusion to those exposed to it.	Activity supervisor must be given instruction to strictly prohibit ignition activity. Gas detectors must be placed in order to detect gases being released. Provide trainings to workers related to the hazards of fire. Design an emergency plan for fire to use in case of

Hazard Category And Hazard	Consequences	Required Actions
		emergency.
Temperature Increase in temperature of workplace due to accumulation of ammonia, liquified LPG, carbon dioxide and naphtha.	Exposure to high temperature due to accumulation of hot gases causes respiratory issues like problem in breathing, coughing and dizziness. Exposure for longer time causes cardiovascular diseases to those exposed to it. However, some issues like heat stroke, problem of eczema can also occur to those exposed to high temperature.	Strong ventilation system must be installed to maintain temperature. Place gas leakage detectors at workplace that impact health of workers. Full face respirators must be provided to workers working in workplace.
Noise Noise produced from drying unit, compressors, flash separators reactor, absorbers and prilling unit.	Noise coming from different sources is vulnerable for those exposed to it. As it causes mental health issues like problem in sleeping, disturbance in completing task on time, issues like stress and high blood pressure problems. Most commonly issue of noise induced hearing loss, tinnitus is majorly faced by long term exposure causes cardiovascular diseases also.	Provide ear plugs to those working at noisy area. Install noise absorbing foam in walls around noise producing sources. Grease the machines or noise producing sources on regular basis. Working hours of workers must be reduced to prevent from hazard of noise.
Vibrations High amplitude vibrations produced from prilling unit, reactors, coolers, driers, evaporators and scrubbers.	Vibration induces numbness in feets, hands and fingers that becomes problem when handling equipments. White finger disease may occur to those exposed to vibrations. It also causes issues like blood vessel damage in hands and divert the mindset of those exposed it.	Toe band must be placed under machines producing vibrations. Reduce the working hours of workers working at workplace. Provide rubber gloves to handle the equipments with grip. Install liners inside machines producing vibrations.

Hazard Category And Hazard	Consequences	Required Actions
Confined spaces Leakage of hydrogen sulphide gas inside the tunnels.	Exposure to the hydrogen sulphide gas causes many issues like dizziness, headache, stomach upset, insomnia, eye infection, irritation to respiratory tract and unconsciousness. Exposure to the hydrogen sulphide gas for longer period of time causes those exposed to it to go into state of coma and sometimes death of them	Install gas leakage detectors inside confined spaces. Do not allow workers to work inside confined space without permits. Do not allow any ignition activity to be carried out near confined space. A whole watcher must be hired to not to allow any visitor to enter such place. Install strong exhaust fans to remove gases from tunnels. Workers must be given training regarding importance of use of PPEs.
Manual handling Carrying heavy fertilizer bags on shoulders to warehouse from packaging unit.	Muscular disorder usually occurs during manual handling, as lifting of heavy bags can cause damage to not only shoulder muscles but also damage to the spinal cord. Repetitive movement can cause vertebra dislocation also.	Reduce the injuries of manual handling by reducing the weight of load. Reorganize the task by sharing the load with other workers. Wheelbarrow must be used to avoid manual handling. Provide non slippery footwear to avoid slipping during manual handling. Ensure proper rest breaks are provided to the workers lifting heavy weight.

5. Gaps

Following are the gaps found in the literature reviewed here:

Most of the studies lacked comparative analysis of non-exposed group to determine occupational health and safety hazards in fertilizer industry.

A very few up-to-date national and international publications are available on occupational health and safety hazards in Fertilizer industry.

In the available literature, health hazard due to poor lighting in the working area is almost neglected.

Radioactive hazards in the fertilizer industry due to utilization of complex raw materials are not

assessed and few publications are available in this regard.

6. Recommendations

Based on the review, following safe practices are recommended:

Continuous workplace surveys using the OSH inspection checklist to ensure the existence and application of safety practices and measures.

Continuous evaluation of risks in the workplace by members of the OSH committee for risk analysis and risk identification to specify the appropriate preventive and control measures.

Using reliable and effective workplace environmental monitoring devices for detecting that emissions from all process are within permissible limits during every work shift.

Regular training of employees regarding safe work practices, emergency response, proper use of personal protective equipment and occupational risks associated with fertilizer industry.

Periodic health check-ups and employee surveys for early detection and management of health risks.

Periodic accreditation and mandatory training for OSH committee members in basic and advanced occupational safety and health (OSH) courses.

7. Conclusion

The workers working in the fertilizer industry may get exposed to different hazards such as chemicals (i.e., xylene, benzene, toluene, CO), high temperature, fire, mechanical hazards, slips and falls, noise and low light damaging vision. In order to minimize these hazards, several measures need to be taken including continuous risk assessment of the fertilizer industry to identify potential hazards, proper training of workers, efficient and effective use of PPEs and periodic medical examination for early detection and management of health hazards.

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