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Biomedical Wastes: Sources, Impacts on Aquatic Environment and Management

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Abstract

Biomedical waste generated from healthcare institutions and laboratories, is a potential danger to the human health as well as non-target organism like fish. This type of waste contains various pathological, pharmacological, genotoxic, chemical, and radioactive materials. This article highlights the various types of biomedical waste, their sources, impacts on aquaculture, fisheries as well as their disposal. The article also focuses on the negative impacts of microplastics generated from the degradation of various biomedical waste on fishes. Proper segregation, disposal, and awareness about the impacts of biomedical waste when not disposed properly is the need of the hour. As we strive for sustainable healthcare practices, it is crucial to implement effective waste management strategies in healthcare institutions and laboratories to mitigate potential health hazards. By prioritizing responsible waste handling, we contribute to a more robust, healthier and sustainable future for both our communities and the planet.

KEYWORDS

Biomedical waste, Antibiotics, Aquaculture, Health Hazard, Pathogens

INTRODUCTION

Biomedical waste is a term that encompasses any waste, whether solid, liquid, or in between, as well as the container and any by-products produced during the diagnosis, treatment, or vaccination of people or animals. Biomedical waste can spread various infections to humans, aquatic animals, animals, crops or natural ecosystem. This category of waste encompasses a diverse range of materials, such as pathological waste, microbiological waste, pharmaceutical waste, sharps (needles and syringes), and other potentially infectious materials. Before delving into the origins and impacts of biomedical waste, it is essential to familiarize ourselves with certain terminologies:

TERMINOLOGIES IN BIOMEDICAL WASTE

Solid Waste: This includes items like disposable medical equipment, paper, and other solid materials generated in healthcare settings.

Biomedical Waste: This category includes the wastes generated during diagnosis, treatment of diseases, research studies, animal slaughtering and in the field of veterinary.

Medical Waste: Wastes originating from the diagnosis, treatment, research, production, and testing of biological materials.

Solid Waste: This includes items like disposable medical equipment, paper, and other solid materials generated in healthcare settings.

Hospital Waste: Hospital waste can contain various Non-hazardous (85%), Infectious (10%) and Hazardous (5%) wastes.

Pathological Waste: Wastes generated from human sources like human tissues, organs, bodily fluids, Postmortem examination and anatomical dissection.

Genotoxic Waste: This includes waste that are genotoxic in nature, i.e., cause damage to the DNA or genetic information. It includes certain cytotoxic drugs that are used in cancer treatment. Special precautions are taken to handle and dispose of this waste safely.

Infectious Waste: These are the wastes which are capable of transferring bacterial, viral or parasitic infection to human and other living organisms.

Hazardous Waste: This category includes radioactive substances, chemicals, gaseous wastes, cytotoxic drugs, outdated drugs, etc.

SOURCES OF BIOMEDICAL WASTE

Veterinary clinics, dispensaries, hospitals, nursing homes, and blood banks are examples of primary sources. Additional sources include homes, businesses, schools, and research facilities.

PROBLEMS OF BIOMEDICAL WASTE IN AQUACULTURE

Improper disposal without careful adherence to strict regulations can result in issues for various animals, including fish. The impact is primarily associated with the potential contamination of water bodies, which can harm aquatic organisms, disrupt ecosystems, and have cascading effects on fisheries. Here are some of the key effects of biomedical waste on aquaculture:

Water Contamination: Biomedical waste often contains hazardous toxins, chemicals, pathogens, and pharmaceutical residues which can contaminate the water. If not disposed properly, these substances can leach into water bodies, contaminating the aquatic environment. When used, it could affect the health of fish and other aquatic organisms. Water quality degrades as pollutants leach from waste disposal sites into groundwater. Compounds such as Poly Aromatic Hydrocarbons, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and ash contribute to groundwater pollution. Additionally, heavy metals such as Aluminium, Chromium, Manganese, Cobalt, Nickel, Lead, and Iron can also infiltrate and contaminate the water.

Bioaccumulation: Bioaccumulation is the process by which chemicals, and other toxins gets accumulated in an organism when the intake beyond the body's rate of elimination. Microplastics (MPs) have the ability to get accumulated in an organism within each trophic level. Previous research has indicated that the buildup occurs when prey from lower levels of trophic differentiation is consumed by organisms in higher levels of trophic balance. Certain chemicals and pharmaceuticals present in biomedical waste may undergo bioaccumulation in fish tissues. As fish consume contaminated prey or water, the pollutants can accumulate in their bodies with time. This bioaccumulation can lead to elevated concentrations of harmful substances in fish, posing risks to both aquatic life and raising health concerns who consume the fish. Different types of algae, such as Chlorella and Scenedesmus, have been observed to absorb microplastics (MPs), resulting in decreased photosynthesis and growth inhibition from reactive oxygen species production. Filter-feeding bivalves such as oysters, clams, and mussels commonly encounter plastic and typically consume microplastics which can cause detrimental effects in the physiology of the organism. Earlier research has indicated that ingestion of microplastics smaller than 10 µm by the blue mussel (*Mytilus edulis*) leads to the accumulation of MPs in the gut and subsequent absorption into the circulatory system. Additional evidence suggests that fish in European water bodies have encountered alterations in their reproductive development when exposed to ethinyl estradiol (EE_2), a substance found in oral contraceptives (Rehberger *et al.,* 2020).

Disruption of Ecosystem Balance: The presence of hazardous as well as infectious substances from biomedical waste can alter the natural balance of aquatic ecosystems. This could affect the abundance and diversity of fish and other aquatic species, leading to ecological imbalances and significant declines in fish populations. Within the pond, waste accumulation is associated with decreased redox potential while the production of harmful gases like hydrogen sulphide, methane, cause stress and pose several health risks. Mainly in aquaculture sector, over use of medicinal substances like antibiotics, disinfectants, pesticides, herbicides, therapeutants and anaesthetics are known to have adverse effects on fish. It also affects larval growth & inhibit defense mechanisms. External stress and pathogens can make some species more sensitive, resulting in various problems including growth retardation.

THE EFFECTS OF WASTES ON FISHERIES

1. Wastes cause health problems for marine & fresh water fish & in turn for the people who eat those fish.
2. Waste is linked to fish diseases, reproductive problems & mutation.
3. Chemicals & pesticides enters fisheries through ground & surface water & through the air. Fish become contaminated & passed on to other animal & humans through food chain.
4. Medicinal waste dumped in the ocean might expose swimmers to serious disease such as HIV & Hepatitis.

TOXICITY, HEALTH RISKS, AND BIOMARKERS ASSOCIATED WITH MICROPLASTICS PRODUCED AMID THE COVID-19 PANDEMIC

The pandemic produced a substantial amount of biomedical waste, endangering both the natural world and public safety worldwide. Biomedical debris that includes plastic has the capacity to transform into microplastics, measuring less than 5mm, when exposed to sunlight. This conversion occurs through oxidative and thermal processes, as well as the biodegradation of the plastic. Microplastics (MPs) combined with other pollutants such as metals pose a threat to a variety of land and aquatic creatures including mankind. Polypropylene plastics, polystyrene, and polycarbonate are potential contributors of microplastics (MPs) in both aquatic and terrestrial ecosystems. Previous research has revealed that the accumulation of microplastics sized at 24 and 27 nanometers resulted in changes to the feeding and shoaling behavior, as well as disturbances in metabolism and brain structure in Crucian Carp (Carassius carassius) (Ding et al., 2018). Also, when Zebrafish (*Danio rerio*) was exposed to Polystyrene microplastic particles of 70nm, 5μm, and 20μm size, it resulted in inflammation and lipid accumulation and an increase in anti-oxidative stress enzymes in gills, gut, and liver was observed (Lu *et al.,* 2016).

EFFECTS OF USE OF ANTIBIOTICS IN AQUATIC ECOSYSTEMS

Antibiotic Resistance: The transfer of antibiotics into the water bodies can create certain antibiotic resistant bacteria in fish. Exposure to sub-lethal concentrations of antibiotics can result in the selection of resistant strains, that can then spread to other organisms, including those with ecological or economic importance.

Impact on Microbial Communities: Antibiotics in biomedical waste can disrupt the natural microbial communities in aquatic environments. This disruption may affect the balance of beneficial bacteria and other microorganisms that play crucial roles in nutrient cycling and overall ecosystem health.

Bioaccumulation in Fish: Fish can accumulate antibiotics from water and sediments through their gills and skin. This bioaccumulation can lead to higher concentrations of antibiotics in fish tissues. Over time, the accumulation of antibiotics may impact the health of fish and other organisms in the food web.

Altered Behaviour and Physiology: Exposure to antibiotics can affect the behaviour and physiology of fish. Changes in feeding, reproduction, and overall health may occur, potentially leading to population-level impacts in the long term.

Ecological Imbalances: Antibiotics in water bodies can disrupt the ecological balance by affecting various components of the aquatic ecosystem. This includes changes in the abundance of certain species, disruptions in predator-prey relationships, and alterations in the overall biodiversity of the ecosystem.

Transfer to the Human Food Chain: If fish are exposed to antibiotics and accumulate them in their tissues, there is a potential risk of these substances entering the human food chain. Consuming fish with antibiotic residues can create antibiotic resistance and give rise to health risks in humans.

MEDICAL WASTE ELIMINATION

Segregation: On the production site, biomedical waste is separated which includes wards, operation theatres, ICUs, pharmacy, autopsy room, etc. Segregation helps to differentiate wastes into different categories, such as sharp objects, chemical-based medicinal, transmissible, and pathological waste.

This initial step ensures that each type of waste is appropriately handled and treated. Advantages of segregation are as follows:

a) The general waste does not mix with the infectious waste and become infectious.
b) Segregation also reduces the probability of incidence of an infection.
c) Non-infectious waste can be recycled.

Disinfection: This step is crucial to remove various pathogens and disinfect the infectious tissues before disposing them off.

The different methods used in the disinfection process include the following:

a) Thermal: Dry/wet autoclaving is used for the eradication or removal of pathogens from the waste.
b) Chemical: Application or use of chemicals like Formaldehyde, sodium hypochlorite, ethylene oxide, bleaching powder to disinfect the wastes.
c) Use of UV rays: The wastes are disinfected by process of Irradiation and exposing them to ultraviolet rays.

Storage: The waste must be kept at the location of its generation, with security measures in place to deter unauthorized individuals and scavengers from accessing the waste material. If the hospital possesses its own disposal facility, such as an incinerator, the waste can be transported there using appropriate garbage trolleys."

Transport: The waste can be transported within the hospital (internal) or from the hospital to the final disposal site (external).

Final Disposal: Final disposal of waste varies depending on its category of waste. Non-infectious waste like papers can be recycled, whereas biodegradable wastes can be used for landfill or vermiculture. Infectious solid wastes are disposed by incineration. Liquid waste which are infectious in nature are first disinfected and flushed out in the drains.

CONCLUSION

The generation of biomedical wastes is rising day by day and if not disposed carefully might lead to various problems in aquatic as well as terrestrial ecosystems. To mitigate these effects, it is crucial to implement proper disposal methods for biomedical waste, especially antibiotics. Effective and proper management of biomedical waste is a global concern which is recognized by various government and non-government organizations. Various health hazards/problems can occur if toxic wastes containing pathogens are not disposed of with proper care. Education regarding the health risks associated with improper waste disposal is the need of the hour. An important avenue for future research involves predicting the global movement of biomedical waste, employing different methodologies, and conducting quantitative and qualitative evaluations.

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