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Antibiotic resistance in aquatic micro-organisms: The influence of heavy metals.

Shivam Choudghal[1], *Rojin G Raj[2]

Department of Pharmacy Practice, ISF College Of Pharmacy, Moga, Punjab, India.

***Corresponding Author: Rojin G Raj**

ABSTRACT

Antibiotic resistance and heavy metal pollution in water bodies are becoming more prominent concerns throughout the world, since heavy metal tolerance in bacteria is a contributing factor to the emergence of antimicrobial resistance. Recently, researchers established a link between heavy metal exposure and antibiotic resistance in bacteria; in both cases, similar mechanisms exist to allow bacteria to survive in adverse settings while producing antibiotic resistance. Several co-resistance mechanisms may be found on the same plasmid or genetic element, or they may be found on different chromosomal materials. Heavy metals are released into the environment by several industrial and domestic activities, which pollutes and contaminates land and water bodies. Heavy metal concentrations in bodies of water are continuing to grow, exposing the present bacterial variety to tolerance mechanisms and allowing them to develop a larger degree of resistance to heavy metals over time. When these bacteria are exposed to antibiotics in the future, they will activate and express previously developed mechanisms, which will enable them to survive at high dosages with relative ease in the future. Antibiotic and heavy metal resistance in aquatic bacteria is increasing, which may have ramifications for environmental, therapeutic, and drug development investigations, among other things.

Keywords: Resistance, Water Bodies, Antibiotics, Germs, Heavy Metals.

INTRODUCTION

A wide variety of microorganisms may be found throughout nature, and they are involved in the majority of a living organism's biological activities both directly and indirectly. The acceleration of modernization is being driven by industry, urbanization, and shifting lifestyles, leading in a rise in the presence of antibiotics and heavy metals in microbial ecosystems and the extinction of many species. Overall, metals and minerals contribute significantly to the metabolic processes, cell formation and reproduction, and other biological activities. The usage of antibiotics has grown in recent years, paralleling the rise in human lifestyle illnesses. This has resulted in the discharge of a substantial quantity of unmetabolized pharmaceuticals into sewer systems, poisoning water bodies. There are a variety of additional human activities that have raised the concentration of antibiotics and metals in aquatic environments. Increasing the quantities of antibiotics and metals over the tolerance limit serves as an evolutionary driving force for adaptability in hazardous situations. As a consequence of the heavy metals and antibiotic stress, the genetic makeup of bacteria's chromosomal and plasmid DNA changes. This happens as a result of mutations in the DNA and the transfer of genetic elements from resistant bacteria in the environment. Metal tolerance was achieved by the evolution of mechanisms such as efflux, precipitation, complexation, accumulation, and reduction of metal ions, as well as the development of a terminal electron acceptor in metal during anaerobic respiration. A large number of articles have shown heavy metal tolerance in a range of bacteria, and it has been identified as a plasmid-borne resistance gene, similar to antibiotic resistance, in several of these bacteria. By using the efflux system, these plasmids harbouring mobile resistance genes may be easily transmitted and disseminated within the bacterial population, where they are passed on to the next generation of bacteria. It is possible to validate the presence of both genes on a single plasmid by doing a curing experiment on the plasmid in question. It has been shown that the presence of antibiotic and heavy metal resistance genes on the same plasmid is common. Potentially hazardous bacteria are continually being introduced into the environment via water bodies from hospitals and sewage treatment facilities, and these bacteria may contain a mobile genetic element such as plasmids, interns, or transposons, which may make them more difficult to detect. In addition, these horizontally transferable genetic elements may be acquired by other non-pathogenic bacteria, with the consequence that these nonpathogenic bacteria might evolve into pathogenic or virulent strains as a result of acquired resistance to a variety of antibiotics. Infections transmitted by genetic elements such as plasmids, transposons, and integrons that confer antibiotic resistance have been seen often, notably in hospital isolates. Antibiotic resistance and metal tolerance may also be co-selected in the same manner. When Pseudomonas aeruginosa isolates were exposed to a low quantity of zinc, resistance to the antibiotic imipenem was established in the organisms studied. The OprD porin gene was repressed in a mechanism that prevented the antibiotic from entering the cell. Similar to this, researchers observed that copper was capable of inducing bacteria to acquire resistance to imipenem when exposed to high levels of the metal. Metal ions found in hospital discharge fluids or other settings, according to these findings, may contribute to the creation of antibiotic resistance or may be implicated in its development. Because antibiotic and heavy metal resistant genes are frequently associated with mobile genetic elements, metal pollution frequently promotes the formation of antibiotic resistance in bacteria that is exposed to it. Antibiotic resistance is becoming an increasingly serious problem in both routine and clinical settings.

The emergence of heavy metal resistance in microorganisms found in water is a long-term process.

The bulk of heavy metals, such as cobalt, copper, chromium, manganese, nickel, and zinc, are needed in trace amounts for the metabolic activity and growth of microorganisms, but only in small amounts. A wide range of animals suffer from the effects of elevated concentrations when they surpass certain threshold values. However, while some heavy metals, such as cadmium, mercury, and lead, have no biological function and only have a negative impact on microorganisms when present in extremely small amounts, the majority of industrial effluent contains a high concentration of heavy metals that pollute nearby water bodies and an ever-increasing concentration of metals that are exposed to microorganisms that exist in those bodies of water. These steadily increasing amounts of dangerous metals resulted in the emergence of tolerance to them. In order to avoid succumbing to increased concentration stress, bacteria that are hindered by heavy metals have developed other strategies of survival. The ability to withstand heavy metal exposure may be conferred via mobile genetic factors, chromosomal abnormalities, and learned adaptive mechanisms such as:

- Metal ion efflux from the exterior of the membrane.
- Inside or between the cell membrane, metal ion buildup and complexation occur.
- Reduced oxidation state of metal ions in the third step.
- Mutation of cell-targeting proteins and their interacting proteins.
- To simulate antibiotic resistance, increase the production of exopolysaccharides in order to bond metal ions outside the membrane.

Bacterial co-resistance to metals and antibiotics as a result of the emergence of resistance.

It is described as the presence of two or more tolerant/resistance genes on a single mobile genetic element that is capable of transferring information, which is referred to as co-resistance. Environments where heavy metals and antibiotic resistance genes may be found coexisting include gastrointestinal tracts, soil, water, animal dung, and poultry farm sites, to name a few examples. For the same reason that heavy metals are a permanent substance that cannot be destroyed or converted into any other state other than that of oxidation, inorganic accumulators such as heavy metals may be found in all organs and tissues of living creatures. It has been shown, however, that a number of antibiotics are pseudo-persistent, which means that they enter the environment on a constant basis via a variety of ways and remain there. A variety of natural environments, including microbial communities, have been shown to be susceptible to antibiotic resistance and even multidrug resistance among bacteria as a result of heavy metal and antibiotic co-contamination. This has been shown in many studies. Consider the following example: it seems that co-exposure to zinc (Zn) and an antibiotic (Oxytetracycline) in activated sludge bioreactors boosts the bacterial community's resistance to antibiotics. Agriculture soils that have been treated with copper have been shown to increase antibiotic co-selective resistance to antibiotics such as ampicillin, chloramphenicol, and tetracycline (Cu). Metals such as nickel (Ni) and cadmium (Cd) have been shown to promote antibiotic resistance in bacteria grown in microcosms with these metals. There may be a link between increased drug resistance and the presence of heavy metals, which may have aided the enrichment and proliferation of indigenous bacteria among bacterial populations that already had drug resistance genes. Due to the cohabitation of heavy metals and antimicrobial resistance in the environment, it is possible that resistance in antibiotic-sensitive bacteria will be imported as a consequence of this coexistence. As a result, according to their results, some researchers have established a positive association between the frequency of heavy metals resistance genes and increasing levels of heavy metals and antibiotics in the environment. Genetic resistance determinants are transferred to a bigger element via the usage of integral elements, which are genetic elements known as integrons that are present within transposons and are present in the genetic elements known as transposons. Regarding co-resistance, it has been discovered that the transposons (Tn21 and Tn21) are the topic of the most extensive investigation. A Hg-resistance operon and an integron are present in both, and they are responsible for the enormous number of antibiotic resistance genes that can be identified in the genome of an organism. It has been determined that the integron In2 was acquired at Tn21 during evolution, and that this integron was subsequently used to get antibiotic resistance genes for streptomycin and spectinomycin resistance. The Hg-resistance operon in Enterococcus faecium was identified when it was put within a transposon. It was also detected in a conjugative plasmid that included streptomycin resistance and was included inside a transposon. It is critical for the survival of medicinal and environmental bacterial diversity that transferable elements (transposons) play an important role in the co-selection of drug and heavy metal resistance. Following the results of these research, a large number of studies have shown that Tn21 and Tn21-like transposons are found in both pathogenic and non-pathogenic bacteria, respectively.

Significance

A rise in antibiotic resistance genes, diffusion of antibiotic resistance genes, and pathogen acquisition of antibiotic resistance genes are all related with an increase in morbidity and death. Because of the widespread misuse of antibiotics in both human and veterinary settings, as well as the emergence of clinically relevant antibiotic resistance genes and antibiotic resistant bacteria as a result of human activities, antibiotics have evolved into a significant environmental hazard that has the potential to result in death in humans. Between now and then, the risk assessment approaches that are now in use to determine the impact of antimicrobials as well as antimicrobial resistance genes on the creation and selection of resistance continue to be ineffectual. When compared to biodegradable chemical toxins and pollutants, bacteria are tenacious, capable of multiplying and spreading throughout the environment, and they are not easily killed. A variety of different mechanisms allow the drug resistance genes of these bacteria to spread throughout their hosts, where they are subject to evolution and may be transmitted to new bacterial populations. It is a major source of worry in the context of infection control and health-risk prevention activities when resistance genes are transferred from one group to another.

CONCLUSION

Heavy metals such as cadmium, mercury, copper, and zinc have a substantial effect on soil and water habitats that are impacted by agriculture and aquaculture. The toxicity of these metals to soil and water microorganisms varies depending on their composition. Several of these metals enter and persist in the environment, where they build up to harmful amounts, causing pollution and health risks. Aside from damaging the soil and water environment, they also contribute to antibiotic resistance co-selection via the mechanisms mentioned in the preceding section. In addition, a detailed investigation of the mechanisms that lead to the acquisition and transfer of drug and metal resistance is necessary to be conducted. In parallel, adequate risk assessment models and management techniques must be developed as soon as possible in order to put a stop to the spread of resistance genes and to protect human health and the environment in general.

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