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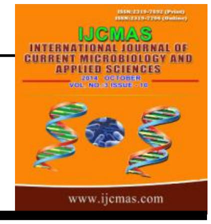

Review Article

Genotoxic Hazard of healthcare Wastewaters: A Review

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A B S T R A C T

The health care industry has got a new dimension through the pharmaceutical industries, clinical laboratories & diagnostic centres located in every parts of India. These units are supposed to safeguard the health of the community but they releases a substantial amount of liquid waste generated during manufacturing, diagnosis purpose along with labware washing and laboratory cleaning. These wastewaters are a heterogeneous mixture including toxic chemicals which may have an impact on the environment and human health. In many low-income countries, healthcare waste rarely receives special attention rather, it is handled as part of the municipal waste stream. Chemical residues present in heathcare wastewater discharged into the sewerage system have adverse effects on the operation of biological sewage treatment plants or toxic effects on the natural ecosystems of receiving waters. Indeed, some of the substances found in healthcare wastewaters are genotoxic and are suspected to be a possible cause of the cancers observed in the last decades. Therefore special care in handling genotoxic waste is absolutely essential; any discharge of such wastewater into the environment for long time could have disastrous ecological consequences. This article summarizes the genotoxicological scenario of the healthcare wastewater and provides suggestions that wastewater should be handled and treated according to its type. Besides, there should be a regular monitoring tool for assessing the wastewater discharged from health care units to ascertain that effluent discharged from clinical diagnostic Centres and pharmaceutical industries are safe.

Introduction

Healthcare institutions are service-oriented establishments that provide medical care facilities comprising of observational, diagnostic, research, therapeutic and rehabilitative services and serves a vital role in helping to improve the well being of all members of society. Health care facilities encompass a wide range of types, from small and relatively simple medical clinics to large complex and costly teaching and research hospitals. These health-care facilities, microbiological research laboratories, diagnostic laboratories, pharmaceutical firms and funeral homes have always generated a wide variety of waste components. These facilities are among the largest generators of waste, of which 10-25 % of health care waste is regarded as hazardous and may create a variety of health risk.

The occupational and public health risks associated with the components of the waste stream (these types of waste will be referred to as health-care waste or HCW) have not been completely well assessed.

Despite the attention given to medical waste by the public and all levels of government, the terms hospital waste, medical waste, regulated medical waste and infectious waste remain poorly defined. According to BAN & HCWH, 1999, Healthcare Wastes are defined as "any solid or liquid waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in research laboratories, or in the production or biological testing". India has witnessed accelerated activity in clinical waste disposal but like in many other developing countries disposal of clinical wastes has been handled very casually thus with time it has assumed the crisis management problem. Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, agriculture and health care units such as hospitals, clinical laboratories & diagnosis centres as well as pharmaceutical establishments. Since water is active in carrying soluble matter around; not just nutrients for the plants but also pollutants originating from human activities in households, agricultural, healthcare establishments, industrial activities travel into the landscape and cause biological damage to water dependent entities.

Thus, Wastewater is one of the main issue in the context of the pollution not only devasting to human but also to animals. Polluted water destroys aquatic life and reduces its reproductive ability. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers. If water is badly polluted-- like raw sewage--- it might be obvious from its appearance or odor. It might be colored or turbid (cloudy), or have solids, oil or foam floating on it. It might have a rotten odor, or smell like industrial chemicals. A lot of dead fish floating on the surface of a lake would be a clear sign that something was wrong. But
many harmful-- and beneficial-- materials in water are invisible and odorless. In order to go beyond the obvious, to determine what materials are in the water, and how much, we need to be able to conduct chemical or microbiological analyses. As one of the crucial and utmost important community services provided, the healthcare sector alone involves the usage of massive amounts of water throughout its operation (Kummerer 2001).

Over the years, scientists and environmentalists have discovered that wastewater produced by hospitals possesses a destructive property of bearing particular chemical and pharmaceutical elements capable of causing environmental impacts and even lethal effects to the global aquatic ecosystems (Sprehe *et al*. 1999). Moreover, with the public's increasing demands on healthcare standards, advancements in medical technology and rapid development in the pharmaceutical sciences, the number and complexity of hospital activities have increased and thus have led to more negative impacts through the increase in wastewater production by hospitals. Pollution is a human problem because it is due to recent development in the planet's history. Water pollution is one of the main environmental problem and pollution from toxic chemicals in water threatens life on this planet. Expanding cities are shortening the lapse between the release of treated wastewater into the environment and the uptake by water drinking facilities. Even though wastewater treatment plants usually exceed current discharge standards, the presence of unregulated pollutants in these effluents is of concern (Petrovic *et al*., 2003). Several investigations have shown some evidence that substances of pharmaceutical origin are often not eliminated during waste water treatment and also not biodegraded in the environment (Ternes, 1998; Daughton and Ternes, 1999; Zwiener *et al*., 2000). Studies show that some PhACs (pharmaceutical active component) originating from human therapy are not eliminated completely in the municipal STPs and are, thus, discharged as contaminants into the receiving waters (Heberer, 2002). More than 80 compounds, pharmaceuticals and several drug metabolites have been detected up to the g/l-level in municipal sewage and surface waters located downstream from municipal STPs(R). Positive findings of PhACs have also been reported in groundwater contaminated by landfill leachates or manufacturing residues (Heberer 2002). Many of these chemical compounds resist normal wastewater treatment. They end up in surface waters where they can influence the aquatic ecosystem and interfere with the food chain. Therefore in recent years, increasing attention has been paid to the presence of emerging pollutants in wastewaters, surface waters and ground waters (Daughton and Ternes, 1999; Heberer, 2002; Barceló, 2003; Daughton, 2004; Petrovic *et al.*, 2009).

The sources of health care waste :

Four main sources of disposal of drugs in the environment for use in humans have been identified:

- Excretion by patients in urine or faeces, either in the original active form or in the form of active or inactive metabolite;
- Unintentional or intentional industrial discharges, whether accidental or not, by chemical synthesis or production sites;
- Wastes from unused drugs (UD's) by patients who, instead of returning the latter to a pharmacy, either throw them in their dustbin or down their toilet, or dissolve them in tap water;
- Wastes from university, research or biology laboratories, or even by healthcare institutions (hospitals, clinics) or by outpatient healthcare personnel.

Pathology, microbiology, blood bank and other diagnostic laboratories generate sizable amount of biomedical waste (BMW). The audit of laboratory revealed 8 kgs anatomical waste, 600 kgs microbiology waste, 220 kgs waste sharps, 15 kgs soiled waste, 111 kgs solid waste, 480 litres liquid waste along with 33000 litres per month liquid waste generated from labware washing and laboratory cleaning and 162 litres of chemical waste per month (Chitnis *et al.*, 2005).

Toxicity & hazards of healthcare waste:

"All things are poison and nothing without poison; only the dose determines that a thing is not poison." (Philippus Theophrastus Aureolus Bombastus von Hohenheim, Paracelsus, 1493–1541). Demographic growth throughout the world and drug consumption which is constantly on the increase result in an ever increasing presence of medicinal substances in the various compartments (air, water, soil) with potential repercussions on the environment and on health (Defarges *et al.*, 2011). The existence of a possible exposure of biological, chemical and radioactive substances released by hospital effluents conducts to take into account, the eventuality of a radioactive chemical and microbiological risk for the abiotic system and the living species which populate them (R). Riviere (1998) distinguishes the hazardous products by their capacity to provoke toxic short-term effects (mortality) or in the long-term (appearance of cancers, reproduction problems, etc.). Hospital operations involve the use of multi chemical and pharmaceutical products that degrade the environmental quality. Over the years, some potent hospital disinfectants have been studied for their potential environmental and biological impacts to the surroundings. Meanwhile, the pharmaceutical products used in clinical situations have become another major problem that contributes negatively to the environment, in which the metabolites and substrates that were passed into the public sewage were in fact capable of causing various mutagenic and genotoxic effects on the aquatic organisms (Chan *et al.*, 2005).

Hazardous medical waste consists primarily of chemicals and discarded cytotoxic drugs which find their way into the environment due to improper usage and indiscriminate disposal. Their presence in the environment have been reported to pose serious environmental health risk due to their toxic, genotoxic and/or carcinogenic effect (Akter *et al*., 1999; Shaner, 1997) and could have potential negative effects on the biological balance of natural environment. The complexity of the problem is furthermore aggravated by the very wide diversity of molecules used, essentially excreted via the faecal or urinary route. There are a large number of sources of dispersal, which are both vague (general population treated at home) and specific (pharmaceutical industry, healthcare institutions) (Daughton, 1999).

Persons At Risk:

All individuals exposed to hazardous health-care waste are potentially at risk, including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. The main groups at risk are the medical doctors, nurses, health-care auxiliaries, and hospital maintenance personnel; patients in health-care establishments or receiving home care; visitors to health-care establishments; workers in support services allied to health-care establishments, such as laundries, waste handling, and transportation; workers in waste disposal facilities (such as landfills or incinerators), including scavengers. The hazards associated with scattered, small sources of health-care waste should not be overlooked, waste from these sources includes that generated by home-based health care, such as dialysis, and that generated by illicit drug use (usually intravenous)(R). Clinical laboratories & pharmaceutical drug producing companies are also small but they are significant contributors.

Hazards From Genotoxic Wastes:

The severity of hazards among healthcare workers responsible for handling or disposal of this type of waste is governed by a combination of substance toxicity itself, and the extent and duration of exposure. Exposure to genotoxic substances in healthcare may also occur during the preparation of or treatment with particular drugs or chemicals. The main pathways of exposure are inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals, or wastes, and ingestion as a result of bad practice, such as mouth pipetting. Exposure may also occur through contact with body fluids and secretion of patients undergoing chemotherapy. The cytotoxicity of many anti-neoplastic drugs is cell-cycle-specific, targeted on specific intracellular processes, such as DNA synthesis and mitosis. Other antineoplastics, such as alkylating agents, are not phase-specific, but cytotoxic at any point in the cell cycle. Experimental studies have shown that many anti-neoplastic drugs are carcinogenic and mutagenic; secondary neoplasia is shown to be associated with some forms of chemotherapy (Pruss *et al*., 1999). Special care in handling genotoxic wastes is absolutely essential; any discharge of such wastes into the environment could have disastrous ecological consequences.

Genotoxicity Perspective On Healthcare Wastewater:

Waste water from hospitals is usually referred to as hospital waste and is defined as a special categoryof waste which comprises of all waste, biological or non-biological that is discarded from hospitals/health care centers and not intended for further use (Oyeleke *et al*., 2008). There is a remarkable paucity on data concerning the possible impacts of hospital discharges, direct or indirect, to the environment. However different reviews of the literature have reported the fate of some of pharmaceutical compounds as well as their occurrence and effects in the aquatic environment (Richardson and Bowron, 1985; Halling-Sorensen *et al*., 1998). Few data on the long-term health impacts of genotoxic healthcare wastes are available, partly due to the difficulty in assessing human exposure to this type of compound. A study found a significant correlation between foetal loss and occupational exposure to anti-neoplastic drugs during the first three months of pregnancy (Selavan, 1985). It has been reported that potential health hazards are associated with the handling of antineoplastic drugs, manifested by increased urinary levels of mutagenic compounds in exposed workers and an increased risk of abortion (Kennedy,1988, Stucker, 1990). Further a study has demonstrated that exposure of personnel who clean urinals exceeded that of nurses and pharmacists (Pyy, 1988). These individuals were less aware of the danger, and took fewer precautions. Hospitals represent an incontestable release source of many chemicals compounds in their wastewaters, and which may have an impact on the environment and human health. Indeed, some of the substances found in wastewaters are genotoxic and are suspected to be a possible cause of the cancers observed in the last decades. (Jolibios *et al*., 2006, Gupta *et al*.,2009).

Pollutants of concern present in hospital wastewater belong to different groups, such as antibiotics, X-ray contrast agents, heavy metals, disinfectants, detergents, solvents, pharmaceuticals, and some radionuclide (Dana *et al*., 2005). Hospital waste consists of both organic and inorganic substances including pathogenic microorganisms. The amount of waste water discharged from hospital varies from hospital to hospital but it has been estimated about 400 to 120 liters/bed/day (Tsakona *et al*.,2006) reported an estimate on per capita production of waste water in hospital to be 1000 liters/person/day. The important consumption of water in hospitals further gives significant volumes of wastewater loaded with microorganisms, heavy metals, toxic chemicals and radioactive elements, the majority of which are toxic(R).

Thus it was demonstrated that due to the laboratory activities and the in-patients' excretions of medical metabolites into the wastewater, hospitals are identified to be one of the major release sources and contributors of pharmaceutical chemicals in the aquatic environment (Kummerer 2001). Thus ecological and toxicological problems due to the discharge of wastewaters from these units in sewage system will become one of the most important water pollution problems in near future. Moreover, all individuals exposed to hazardous health-care waste are potentially at risk, including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. (Gupta, *et al.*, 2009). In healthcare units chemicals such as xylene, phenol, methylene blue, hydrochloric acid, chlorine and carbol fuchsin are used for the staining, preservation of slides, for the sterilization and cleaning of equipment and surroundings are potentially harmful to the laboratory technician and the environment (Akter *et al.*, 1998) some of which are probable carcinogens, besides that a huge amount of disinfectants being used which has genotoxic potential (Susan & Richardson, 2007). The Allium cepa test was used to evaluate the genotoxicity of a hospital effluent in Santa Maria, Rio Grande do Sul State, Brazil. Chromosomal disruptions, anaphasic bridges, and micronuclei during telophase were observed, indicating environmental toxicity risk (Bagatini *et al*., 2009). Genotoxicity was also studied with *Saccharomyces cerevisiae* D7 assay and with the induction of chromosomal aberrations in *Allium cepa* test (Paz *et al.*, 2006). An evaluation of the genotoxic potential of different wastewaters collected in the Rouen area was performed with the SOS chromotest (on *Escherichia coli* PQ37) and the Salmonella fluctuation test on *Salmonella typhimurium* strains TA98, TA100 and TA102 with or without metabolic activation (Jolibios *et al.*, 2005). The mutagenic and carcinogenic antineoplastic agent cyclophosphamide (CP) is released into sewage water by cancer patient excretion (Steger-Hartmann *et al*., 1997). Experimental studies have shown that many anti-neoplastic drugs are carcinogenic and mutagenic; secondary neoplasia is shown to be associated with some forms of chemotherapy (Benhamou S, 1986). Some countries especially developing countries are however yet to put down legislature as to reducing the environmental impact of hospital wastewaters. Many health care center/hospitals lack effluent treatment plants, and thus the untreated waste are either deposited on the ground or discharged into nearby natural bodies which may pose serious health problems to communities (Chukwura & Okpokwasili, 1997; Odiete, 1999). In this regard, concerns in areas such as how pollutants from the hospitals contribute negative and drastic impacts to the environment and the oceanic ecosystems remain an urgent matter to be dealt with in order to avoid possible overwhelming environmental problems in the future (Perrodin 1988)

Clinical Diagnostic Centre Wastewater:

The health care industry has got a new dimension through the clinical laboratories & diagnostic centres located in every parts of India in order to provide enough health care services to the people. These units are supposed to safeguard the health of the community but pathology, microbiology, blood bank and other diagnostic laboratories generate sizable amount of biomedical waste (Chitnis et al., 2005) which may have an impact on the environment and human health.

Diagnostic centres and clinical laboratories are present in large number not only in metro or major cities but also in remote cities and villages. Although they are producing small amounts of waste but since they are present in large numbers, their actual contribution to total waste may be considerable. Besides, water pollution is all about quantities: how much of a polluting substance is released and how big a volume of water it is released into. A small quantity of a toxic chemical may have little impact if it is spilled for short time. But the same amount of the same chemical can have a much bigger impact if pumped out for long time. Thus, these units releases a substantial amount of liquid waste generated during diagnosis purpose along with labware washing and laboratory cleaning. This wastewater is a heterogeneous mixture which includes toxic chemicals but there is no single diagnostic centre which treat this wastewater prior to discharge.

As a result, investigations and environmental assessments must be performed to determine the toxic chemicals and their potential harmful effects to the environment, either alone or with interactions upon other chemical integrations, have become an indispensable part in controlling the toxicity of hospital wastewater in nowadays' context (Jolibois *et al*., 2002) so for clinical laboratories. The findings of the hospital wastewater research (R) have thrown light towards the importance of monitoring and regulation of future negative impacts that may arise from clinical diagnostic centres and laboratories wastewater. Similar to hospital effluents, wastewaters discharged from clinical laboratories & diagnostic centres also contain a variety of toxic or persistent substances such as pharmaceuticals, antibiotics, radionuclides, solvents, reagents and disinfectants for clinical purposes in a wide range of concentrations due to laboratory and research activities. Most of these compounds belong to the so called emerging contaminants; quite often unregulated pollutants which may be candidates for future regulation depending on research on their potential health effects and monitoring of their occurrence (Verlicchi *et al.,* 2010).

Since the chemicals to which people are exposed, either intentionally, in the course of their daily life, or inadvertently are tested for their potential to produce cancer and genetic damage (mutations). Therefore, study on clinical laboratories & diagnostic centre effluents is thus relevant due to the toxicity of healthcare wastes and associated mutagenicity as well as review of available information on hospital wastewater, as relates to their nature and impacts. In fact, to conserve the entire global environmental integrity as well as to help maintaining a sustainable development for the future generations, the focus on the possible environmental impacts of healthcare wastewaters and the feasible mitigation measures has become an area not to be neglected in the contemporary context of environmental conservation and management.

Genotoxicity Evaluation of Healthcare Wastewater:

Live organisms are frequently exposed to environmental agents that induce mutations. Therefore detection of these products are important (Costa and Menk 2000; Silva *et al.,* 2003; Paz *et al.,* 2006). Specifically genotoxins in water are of interest because epidemiologic investigations have shown a link between genotoxic drinking water intake and a rise in cancers (Koivusalo *et al.,* 1994, 1995, 1997). The impacts caused by toxic agents on the genetic material, often are not capable of being observed and measured directly. Information obtained through biomonitors permits estimating and comparing these impacts (Bagatini *et al*., 2009). Therefore, genotoxic chemical emissions from anthropogenic activities into environmental compartments require genotoxicity assays for the assessment of the potential impact of these sources on the ecosystems and on human health (Rank 2003). Since large quantities of chemicals and products are used in healthcare centres, such pollution due to healthcare wastewater may occur on a significant scale. Assessment of genotoxicity of effluent discharged from healthcare centres is therefore of utmost importance. Although more than a hundred "test systems" for investigating genotoxicity have been described in the literature or used in practice, ranging through the biological phyla from bacteriophage to mammals, less than 20 are in regular use and some of these are only available in specialized laboratories. The most widely-accepted systems are summarized below.

Plant assay:

Because of the tremendous advances made in the use of microbial and mammalian cell procedures in genetic toxicology, plant material is less often used for studying mutagenic chemicals than previously. However, the use of plants such as the bean (*Vicia faba*), onion (*Allium cepa*), spiderwort (*Tradescantia paludosa*), maize (*Zea mays*), barley (*Hordeum vulgare*), and soybean (*Glycine max*) may have significant advantages over other systems and their value in screening chemicals for mutagenic activity has still to be fully explored. Investigation of genetic changes at both the gene and chromosomal level can be conducted in plants without the complicated laboratory facilities required for other types of assay and this may be a great advantage under certain circumstances.

(a) *Allium cepa* Test:

Allium cepa test is one of the most used plant species in toxicity and genotoxicity tests, particularly when monitoring effluents. Although a number of species of *Allium* have been used for genetic studies, the common onion, *Allium cepa*, has proved to be the species of choice for root-tip chromosome studies (Grant, 1982).

(b) *Tradescantia paludosa*

Compared to *Allium*, only a few chemicals have been tested for mitotic chromosomal aberrations in *Tradescantia,* but it has the advantage that both meiotic and mitotic chromosomal damage and gene mutations can be tested in the same species. Dividing cells in the root tip of *Tradescantia* contain 12 large metacentric chromosomes. A large number of roots can be obtained from cuttings from mature plants in about a week. These rooted cuttings can then be used for chromosome studies in much the same way as those of *Allium* (Ahmed & Grant, 1972).

Besides a number of animals and fish have also been used for genotoxicity evaluation of a number of environmental samples like surface water (Glos *et al.* 2000: Reifferscheid, G. *et al.,* 2000*:* Schnurstein *et al.* 2001: Scalon, MCS. *et al*., 2010) industrial effluents (Sumathi *et al.*, 2001: Gauthier, 2003).

Microbial Assay:

One of the cornerstones of modern toxicological investigations is the concept of the three R's reduce, refine, and replace, put forward by Russell (2005). The intention is to reduce the numbers of animals used in toxicological experiment, to refine the methods by which they are used, and to replace the use of animals as appropriate alternative methods become available. Therefore microbial assays are promising system designed to evaluate the genotoxicity of environmental substances.

Assays that involve the use of bacteria for detecting mutagenic chemicals are the most extensively used and, in general, the most thoroughly validated.Unlike higher organisms, in which the DNA is organized into complex chromosomal structures, bacteria contain a single circular molecule of DNA that is readily accessible to chemicals that can penetrate the cell wall. Bacterial tests also have the advantage that a population of many millions of cells with a relatively short generation time can be tested in a single assay (WHO-IPCS, 1985). These bioassays are generally performed using cultured organisms & measure the toxic responses after exposure under controlled conditions in the laboratory. Results from these genetic bioassays are relevant to human health because the toxicological target is DNA, which exists in all cellular life forms. Thus, it can be extrapolated that compounds shown to be reactive with DNA in one species have the potential to produce similar effects in other species (Mathur *et al.*, 2007). Some of the most commonly used short term microbial bioassays are:-

AMES Test:

This test is based on a strain of *Salmonella typhimurium* that cannot synthesize histidine. It lacks the enzymes to repair DNA so that mutations show up readily, and has leaky cell walls that permit the ready entrance of chemicals. Many potential carcinogens are mutagenic agents only after being acted on by mammalian liver enzymes, so an extract of these enzymes is added to the test medium. In the control setup, bacteria are plated on a histidine-free medium containing liver enzymes but lacking the test agent. The experimental plate is prepared the same way except that it contains the test agent. After incubation, plates are observed for colonies. Any colonies developing on the plates are due to a back-mutation in a cell, which has reverted it to a his (+) strain. The degree of mutagenicity of the chemical agent would be calculated by comparing the number of colonies growing on the control plate with the number on the test plate (Ames *et al*., 1975)

SOS Chromotest:

The SOS Chromotest is a simple bacterial colorimetric assay for genotoxicity. It is based on the measure of the induction of sfiA, a gene controlled by the general repressor of the SOS system in E. coli. Expression of sfiA is monitored by means of a gene fusion with lacZ, the structural gene for beta-galactosidase. The SOS chromotest is one of the most rapid and simple short-term test for genotoxins and is easily adaptable to various conditions, so that it could be used as an early--perhaps the earliest--test in a battery (Quillardet, Hofnung, 2003). This test is used to evaluate the genotoxicity of many environmental substances such as industrial effluent (Legault *et al.*, 1998), domestic effluent and healthcare waste effluent (Jolibois *et al*., 2003: 2005). Waste water studies using the SOS chromotest were performed in Canada (Legault *et al*., 1996: White *et al.*,1996a: White *et al.*, 1996b, White and Rasmussen 1998, White *et al*., 1998b: White *et al*., 1998a), Austria (Helma *et al*., 1996), Finland (Suominen *et al*., 1998), and Germany (Janz *et al.*, 1990).

Sorption of genotoxins to effluent suspended particulate or detection of genotoxic substances in bivalve molluscs has also been studied (White *et al*., 1996b: White *et al*., 1997).

***E. coli* WP2:**

The *Escherichia coli* WP2 test have been adopted in one EC test guideline (67/548/EEC, B.13/14). The principle of the test is that an *E. coli* strain deficient to synthesise tryptophane reverts to its "wild" type and recovers its ability to grow on tryptophane free agar plates under the influence of mutagens. Compared with others this test has not achieved any considerable importance. Therefore only few data with waste water are documented (Fracasso *et al*., 1992: Codina *et al.*, 1994)

Yeast:

The budding and fission yeasts *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*, respectively, are among the most extensively studied of the eukaryotes and provide convenient tools for use in genetic toxicology studies of environmental chemicals. The internal structure of the yeast cells shows strong similarities to that of the cells of higher organisms, in that they possess a differentiated nucleus containing a nucleolus. The accurate functioning of cell division depends on the synthesis of a spindle apparatus; however, unlike mammalian cells, yeasts and other fungi maintain their nuclear membrane during cell division. Yeast and fungi occupy a position between bacteria and animal cells in terms of genetic complexity. The structure of fungal DNA and its organisation into chromosomes is similar in many ways to that of mammals. Both haploid and diploid forms can be used in genetic assays. Tests using yeasts, such as *Saccharomyces cerevisiae*, are available for detecting both forward and reverse mutations and a variety of other genetic changes. Certain strains of yeast can be used to detect chemicals that induce aneuploidy (i.e., unequal distribution of chromosomes during cell division) and there is some evidence that non-genotoxic carcinogens can be identified using these strains. The primary advantages of yeasts in genotoxicity studies are eukaryotic chromosome organization, variety of genetic end-points can be assayed, cost-effective assays requiring limited technical and laboratory facilities using a "robust" organism (WHO-IPCS, 1985).

As a conclusion assessment of efficacy and safety, the environmental impact and its health repercussions must be taken into account in the future by public decision-makers; it is therefore important for this purpose to provide them scientific enlightenment. Based on the aforementioned paradigm and findings, it is thus important for biologists, chemists, pharmacologists and environmentalists to collaborate and closely monitor the state of healthcare wastewater discharge in order to foster a more “environmentally-friendly” system which would minimize its disturbances on the equilibrium of the ecosystem.

Poor healthcare waste management is widespread in low income countries many people come into direct contact with the waste and are thereby exposed to health risks. Important contributory factors include a lack of awareness of the potential health risks, a consequent lack of motivation to improve the situation and inadequate resources with which to improve practices. Toxicity of wastewater discharged from pharmaceutical manufacturing industries, clinical laboratories and diagnostic centres and their potential genotoxicity probably carcinogenicity which leads to hazardous working conditions for on-site personnel. There has been little quantitative research into the actual impacts (as opposed to perceived impacts) of the risks posed by poor healthcare waste management. Therefore from the environmental toxicology point of view further qualitative/quantitative studies and experimental investigations on healthcare wastewater are required which would be meaningful and it would make us attainable to determine the effects caused on plant and wildlife that exist around the area of discharge of the effluent. Before humans can be exposed to chemicals or other materials, for instance, present in healthcare wastewater, it must be confirmed that this exposure will not endanger human health. This is particularly important in the case of chronic exposures. In this regard, the carcinogenic potential of such material is of great concern since chemical carcinogenesis is often the result of chronic exposure to minimal concentrations.

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