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WATER POLLUTION: IMPACT OF POLLUTANTS AND NEW PROMISING TECHNIQUES IN PURIFICATION PROCESS

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Abstract:- Water is a critical resource in the lives of people who both benefit from its use and who are harmed byits misuse and unpredictability (flooding, droughts, salinity, acidity, and degraded quality). Water is a finite andvulnerable resource. Consequently, consumption of polluted water puts lives and livelihoods at risk because water hasno substitute. There are many ways in which water intended for human consumption can get polluted. These includewastes from industries like mining and construction, food processing, radioactive wastes from power generatingindustries, domestic and agricultural wastes and by various microbiological agents. Nowadays, water is being purified byvarious methods but research is being conducted to look for more reliable and cheaper methods that can purify waterat an affordable cost. Various techniques have been developed like utilizing rechargeable polymer beads, seeds ofMoringaOleifera tree, aerobic granular sludge technology, resin based treatment and two-pronged water treatmenttechnology.

Keywords: Water Pollution, Water Treatment, New Techniques, Pure Water.

INTRODUCTION:

Water is that chemical substance which isessential for every living organism to surviveon this planet. Water is needed by every cell ofthe organism's body to perform normal function.Water covers 71% of the Earth's surface, mostlyin oceans and other large water bodies, with 1.6%of water below ground in aquifers and 0.001% inthe air as vapor, clouds and precipitation (U.S.Geological Survey 2000). Water moves continuallythrough a cycle of evaporation or transpiration(evapotranspiration), precipitation, andrunoff, usually reaching the sea. Winds carrywater vapor over land at the same rate as runoffinto the sea. Over land, evaporation andtranspiration contribute to the precipitation overland. Clean, fresh drinking water is essential tohuman and other life. Some observers haveestimated that by 2025 more than half of the worldpopulation will be facing water-based vulnerability,a situation which has been called a 'watercrisis' by the United Nations (Kulshre-shtha1998). A recent report (November 2009) suggeststhat by 2030, in some developing regions of theworld, water demand will exceed supply by 50%(Charting Our Water Future 2009).

Pure uncontaminated water does not occurin nature. Water pollution is any undesirablechange in the state of water, contaminated withharmful substances. It is the second most importantenvironmental issue next to air pollution.Any change in the physical, chemical andbiological properties of water that has a harmfuleffect on living things is termed as 'waterpollution' (WHO 1997). As a result of the unwantedhuman activities, water pollution is a growinghazard in many developing countries. A moreserious aspect of water-pollution is that whichis caused by human activity, and industrialization(Park 2009). There are also various micro-biologicalagents that include bacteria, viruses andprotozoa which can also cause water pollutionand may cause various water-borne diseases.

The earliest recorded attempts to find orgenerate pure water date back to 2000 B.C. EarlySanskrit writings outlined methods for purifyingwater (Early Water Treatment 2009). Thesemethods ranged from boiling or placing

hot metalinstruments in water before drinking it to filteringthat water through crude sand or charcoal filters.These writings suggest that the major motive inpurifying water was to provide better tastingdrinking water. It was assumed that good tastingwater was also clean. People did not yet connectimpure water with disease nor did they have thetechnology necessary to recognize tasteless yetharmful organisms and sediments in water.Although various techniques have been developedin order to purify water so that it can bemade safe and wholesome but large scalepurification involves lot of finances. Researchis being conducted worldwide in order to developnewer methods which can be used to purifywater and that too at an affordable cost.

The main objectives of this study is tohighlight the impact of various water pollutantswhich have rendered the water unsuitable fordrinking and other domestic purposes and toenumerate new and affordable techniques whichcan be used to purify water for various purposes.

Facts and Figures Related to Water Pollution

Disease spreads by consumption of pollutedwater. It has been estimated that 50,000 peopledie daily world-wide as a result of water-relateddiseases (Nevondo and Cloete 1999). A largenumber of people in developing countries lackaccess to adequate water supply. In South Africa,it has been estimated that more than 12 millionpeople do not have access to an adequatesupply of potable water (Nevondo and Cloete1999). Polluted water also contains viruses,bacteria, intestinal parasites and other harmfulmicroorganisms, which can cause waterbornediseases such as diarrhea, dysentery, andtyphoid. Due to water pollution, the entire ecosystemgets disturbed. Unsafe drinking water,along with poor sanitation and hygiene, are themain contributors to an estimated 4 billion casesof diarrhoeal disease annually, causing more than1.5 million deaths, mostly among children less than5 years of age (WHO 2005). Contaminateddrinking water is also a major source of hepatitis,typhoid and opportunistic infections that attackthe immuno-compromised, especially personsliving with HIV/AIDS (UNICEF 2011). Almost 1billion people lack access to safe and improvedwater supply. More than 50 countries still reportcholera to WHO (World Health Organization).Millions are exposed to unsafe levels of naturallyoccurringarsenic and fluoride in drinking waterwhich leads to cancer and tooth/skeletal damage.

An estimated 260 million people are infected withschistosomiasis (WHO 2004). 1.3 million peopledie of malaria each year, 90% of whom arechildren under 5. Impoverished slum dwellers inAngola draw drinking water from the local riverwhere their sewage is dumped. Farmers on thelower reaches of the Colorado River strugglebecause water has been diverted to cities likeLas Vegas and Los Angeles. In large parts of India, more than 60 percent of city dwellers arein fact slum dwellers. For many of them, watercomes not from faucets inside their shacks butfrom water tankers or standpipes, neither of whichis reliable as a water source. Open sewersincrease the risk of water-borne diseases (UNworks 2010).

HUMAN ACTIVITIES RESPONSIBLEFOR WATER POLLUTION

Virtually all human activities produce somekind of environmental disturbance that contaminatesurrounding waters. Eating (body wastes),gardening (pesticide and sediment runoff) andmany other activities create byproducts that canfind their way into the water cycle. For convenience,we can assign the large majority of sourcesof water pollution to three broad categories ofwaste (Mc Kinney and Schoch 2003).

a. Industrial
b. Agricultural and
c. Domestic wastes

a. Industrial Wastes

Wastes from industry serve as majorsources for all water pollutants. Many majorindustries contribute significantly to waterpollution, but some of the important are the (i)manufacturing (ii) power-generating (iii) mining and construction, and (iv)food processingindustries (Mc Kinney and Schoch 2003).Manufacturing industries like chemical, oilrefining, steel etc. contribute many of the mosthighly toxic pollutants, including a variety oforganic chemicals and heavy metals (Mc Kinneypotential impact but are still considered highly problematic when it comes to pollution. Theseindustries include the textile, leather tanning,paint, plastics, pharmaceutical, and paper andpulp industries (Raja and Venkatesan 2010). Inmany cases, both the products, such as the paintor the pesticide, and the byproducts from themanufacturing process are highly toxic to manyorganisms, including humans.

Power generating industries are the majorcontributors of heat and radioactivity. Nearly allpower plants, whatever the fuel, are majorsources of thermal (heat) pollution. Radioactivityfrom nuclear power plants can pollute waters ina variety of ways, including discharge of mildlyradioactive waste water and ground water pollutionby

buried radioactive waste (Mc Kinneyand Schoch 2003). Radioactivity may be foundin ground waters as well as surface waters. Inground waters it may be due to radioactivematerial present in underground rocks, while insurface waters it may have been passed on witheffluents from uranium mining and enrichmentplants (Rao 2001).

The mining and construction industries aremajor contributors of sediment and acid drainage.There are basically four main types of miningimpacts on water quality (Mining and Water Pollution 2011).

1) Acid mine drainage
2) Heavy metal contamination andleaching
3) Processing chemicals pollution
4) Erosion and sedimentation

Water plays many critical roles within thefield of food science. It is important for a foodscientist to understand the roles that water playswithin food processing to ensure the success oftheir products. Water hardness is also a criticalfactor in food processing. It can dramaticallyaffect the quality of a product as well as playinga role in sanitation. The food processing industryis very diverse. Major sectors include fruit andvegetables, dairy, meats and fish, alcoholic andnon-alcoholic beverages, oils, and packagedfoods. The most common environmentalconcerns in the industry are water consumptionand wastewater discharge, chemicals used inprocessing and cleaning, packaging reductionand disposal, and food scraps and refuse (McKinney and Schoch 2003).

b. Agricultural Wastes

These are generated by the cultivation ofcrops and animals. Globally, agriculture is theleading source of sediment pollution whichincludes plowing and other activities that removeplant cover and disturb the soil. Agriculture isalso a major contributor of organic chemicals,especially pesticides (Mc Kinney and Schoch2003). Pesticides are widely used in modernagriculture in most countries throughout theworld and in a large range of environments. Butenvironmental monitoring increasingly indicatesthat trace amounts of pesticides are present insurface and underground water bodies, far fromthe sites of pesticide application (Voltz et al.2007). The use of nitrogen fertilizers can be aproblem in areas where agriculture is becomingincreasingly intensified. These fertilizersincrease the concentration of nitrates in groundwater,leading to high nitrate levels inunderground drinking water sources, which cancause methemoglobinemia, the life threatening“blue baby” syndrome, in very young children,which is a significant problem in parts of ruralEastern Europe (Yasso et al. 2001). Somepesticides are applied directly on soil to kill pestsin the soil or on the ground. This practice cancreate seepage of pesticides to groundwater orrunoff to surface waters.

c. Domestic Wastes

These are those that are produced byhouseholds. Most domestic waste is fromsewage or septic tank leakage that ends up innatural waters. In the past, some cities dumpeduntreated or barely treated sewage directly intorivers, lakes, or coastal waters. Plant nutrientsoccur in the form of nitrogen and phosphorus.These come not only from human waste, butalso from fertilizers used extensively in householdlawns and gardens (Mc Kinney and Schoch2003). Today, many people dump their garbageinto streams, lakes, rivers, and seas, thus makingwater bodies the final resting place of cans,bottles, plastics, and other household products(Groundwater Quality 2003). Most of today’scleaning products are synthetic detergents andcome from the petrochemical industry. Mostdetergents and washing powders containphosphates, which are used to soften the wateramong other things. These and other chemicalscontained in washing powders affect the healthof all forms of life in the water.

Micro-organisms Causing Water Pollution

There are various micro-biological agentswhich can also cause water pollution if drinkingwater gets contaminated with these agents. Thepathogenic agents involved include bacteria,viruses and protozoa which may cause diseasesthat vary in severity from mild gastroenteritis tosevere and sometime fatal diarrhoea, dysentery,hepatitis or typhoid fever (WHO 1996). Most ofthem are widely distributed throughout theworld. Faecal contamination of drinking water isonly one of several faeco-oral mechanisms bywhich they can be transmitted from one personto another or, in some cases, from animals topeople.Most of the mortality and morbidityassociated with water related disease especiallyin developing countries is due directly orindirectly to infectious agents which infect manthrough:-

1) Ingesting pathogenic bacteria, virusesor parasites (protozoans and helminthes)in water polluted by human or animalfaeces or urine. Diseases in thiscategory include cholera (Cholera

vibrio), shigellosis (dysentery causedby Shigella spp.), typhoid (Samonellatyphi), paratyphoid (Samonellaparatyphi), diarrhea (Escherichia coli),hepatitis (Hepatitis virus) andpoliomyelitis (Polio virus) (Obasohan etal. 2010).

2) Diseases associated with scarcity ofwater for personal hygiene (bathing,hand washing), laundering clothes andcleaning of cooking utensils. In thiscategory of diseases are scabies, yaws,skin ulcers, conjunctivitis and trachoma(Obasohan et al. 2010).

3) Diseases associated with ingestion orpenetration of human skin by infectiveforms that require a snail, fish or otheraquatic hosts. Examples include schistosomiasis,clonorchiasis and paragonimiasis(Obasohan et al. 2010).

4) Diseases from being bitten by insectvector which breeds in or around water.They include malaria, dengue, yellowfever, filariasis (mosquito-borne);trypanosomiasis (tse-tse fly-borne) andonchocerciasis (black fly-borne)(Obasohan et al. 2010).

NEW TECHNIQUES IN WATERPURIFICATION PROCESS

1. Point-of-use Water Purification UsingRechargeable Polymer Beads

'Halo-pure' is one such enabling technicaladvance in the development of an entirely newbiocidal medium in the form of chlorinerechargeablepolystyrene beads that is basedon patented chemistry inventions from theDepartment of Chemistry at Auburn University(Dunk et al. 2005). The discoveries were naturalbut creative outcome of a series of studies,covering more than a decade of research, focusedon stabilizing chlorine on water insoluble,synthetic polymer surfaces.

The fundamental principles of thetechnology are deceptively simple to understand,although their incorporation into a reliablyreproducible and practical medium for watersanitation has taken years of intense effort andresearch. Porous polystyrene beads are similarto those used for water softener resin beds, aremodified chemically so as to be able to bindchlorine or bromine reversibly in its oxidativeform. All that is required is enough free chlorineto surround the binding site. Almost no freechlorine is released when the beads are placedinto the water flow. Typical levels range from0.05 ppm to 0.20 ppm free available chlorine. Thisis not enough to kill anything without lengthyincubation. Hence, the swift efficacy of Halo-puredepends on intimate contact between themicrobes and the bound halogen on the polymer.What you have, then, is a solid surface,effectively biocidal on contact to contaminantsin the water and repeatedly rechargeable whenperiodically exposed to free halogen. In this way,a powerful antimicrobial component can beintroduced into a water purifier that will not runout of steam, and have to be discarded. Instead,it can have its power regularly and conveniently"topped up" by the user. Organisms makecontact with the display of chlorine, for example,on the surface of the beads, and pick up enoughhalogen to inactivate them in short order. Thosenot killed within seconds suffer a near-deathexperience, and succumb quickly in the productwater as the adherent chlorine slowly damagesthe organism to the point of fatal consequences(Dunk et al. 2005).

The technology holds the promise ofreducing the impact of water borne diseasesthroughout the developing world. Its widespreaduse could contribute to the realization of UNgoals for access to safe water for all by 2015.And it could do so without resort to the massiveinfrastructure investments that are needed toreach this goal using more conventional centralizedsanitation and distribution approaches(Dunk et al. 2005).

2. Water Treatment Using the Seeds of theMoringaoleiferaTree

Using natural materials to clarify water is atechnique that has been practiced for centuriesand of all the materials that have been used, seedsof the Moringa have been found to be one of themost effective. Studies have been conductedsince the early 1970's to test the effectiveness ofMoringa seeds for treating water (Paterniani et al.2010). These studies have confirmed that theseeds are highly effective in removing suspendedparticles from water with medium to high levels ofturbidity (Moringa seeds are less effective attreating water with low levels of turbidity).

Moringaoleiferaseeds treat water on twolevels, acting both as a coagulant and an antimicrobialagent. It is generally accepted thatMoringa works as a coagulant due to positivelycharged, water-soluble proteins, which bind withnegatively charged particles (silt, clay, bacteria, toxins, etc) allowing the resulting "flocs" to settleto the bottom or be removed by filtration. Theantimicrobial aspects of Moringa continue to beresearched. Findings support recombinantproteins both removing microorganisms bycoagulation as well as acting directly as growthinhibitors of the microorganisms. While there isongoing research being conducted on the natureand characteristics of these components, it isaccepted that treatments with Moringa solutionswill remove 90-99.9% of the impurities in water(Paterniani et al. 2010).

Solutions of Moringa seeds for watertreatment may be prepared from seed kernels orfrom the solid residue left over after oil extraction(presscake). Moringa seeds, seed kernels ordried presscake can be stored for long periodsbut Moringa solutions for treating water shouldbe prepared fresh each time. In general, 1 seedkernel will treat 1 liter (1.056 qt) of water.

Dosage Rates: Low turbidity NTU(Nephelometric Turbidity Units) <50 1 seed per4 liters (4.225 qt) water
Medium Turbidity: NTU 50-150 1 seed per 2liters (2.112 qt) water
High Turbidity: NTU 150-250 1 seed per 1liter (1.056 qt) water
Extreme Turbidity: NTU >250 2 seeds per 1liter (1.056 qt) water

3. Water Purification Using Aerobic GranularSludge Technology

With the new aerobic granular sludgetechnology, aerobic (thus oxygen using) bacterialgranules are formed in the water that is tobe purified. The great advantage of thesegranules is that they sink quickly and that all therequired biological purifying processes occurwithin these granules (Delft University ofTechnology 2006).

The technology, therefore, offers importantadvantages when compared to conventionalwater purification processes. For example, all theprocesses can occur in one reactor. Moreover,there is no need to use large re-sinking tanks,such as those used for conventional purification.Such large tanks are needed for this because thebacteria clusters that are formed take much longertime to sink than the aerobic granule sludge.The aerobic granular sludge technology isvery promising, and has been nominated for theDutch Process Innovation Award. The technologyis now in the commercialisation phase. Inthe coming years, further research will becontinued. Testing of this purification methodis being done on a larger scale. The firstinstallations are already in use in the industrialsector (Delft University of Technology 2006).

4. Resin Based Treatment for Colour andOrganic Impurities Removal

The rapid industrialization during the lastfew decades has resulted in tremendous increasein demand of water for industries. A largequantity of water used is ultimately dischargedinto water bodies and land as waste water fromvarious unit operations related to variousindustrial processes, and is responsible for theirpollution (Kumar and Bhatia 2007). Attemptshave been made to prevent the adverse aestheticeffects associated with industrial waste waterdischarges by accelerating the removal of colourduring treatment of the variety of industrialwastes. Colour removal is also important if thewater has to be made suitable for drinkingpurpose because many times underground watercomes with colour and this colourhas to beremoved prior to drinking.

Among the manufacturing operations, thetextile dyeing and finishing industries are directlyaffecting colour; which is the most noticeablecharacteristic of both the raw waste and treatedeffluent from this industry. Although biologicaltreatment of these waste waters is usuallyeffective in removing a large portion of oxidizablematter, but it is frequently ineffective in removingcolour. The present method for colour removaluses a green colour basic dye, an anion exchangeresin called ‘Duolite A 171/SC’ and a column madeof borosil glass of height 40cm. From the resultsit was concluded that resin treatment is a bettermethod than conventional biologic process evenat much higher filtration rate (Kumar and Bhatia2007).

CONCLUSION

Water is a renewable natural resource. Dueto ever increasing industrialization, urbanization,this precious resource is continuously understress. There are multiple dimensions to waterquality and its deterioration. Water pollution isrendering much of the available water unsafe forconsumption. The pressure of increasing population,loss of forest cover, untreated effluentdischarge from industries and municipalities, useof non-biodegradable pesticides/ fungicides/herbicides/insecticides, use of chemical fertilizersinstead of organic manures, etc are causing waterpollution. Moreover, there are numerous waterborne diseases like cholera, diarrhoea, dysenteryetc. which are transmitted by drinkingcontaminated water. There are various new waterpurification techniques which have come up topurify water for example by using rechargeablepolymer beads, using the seeds of Moringaoleifera tree, purifying water by using aerobicgranular sludge technology etc. Research isbeing conducted all over the world to developmore and more techniques which can generatepure water at low cost. All these techniques arebeing developed to ensure that in near futureeveryone will have access to clean and purewater and that too at an affordable cost.

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