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Water Monitoring: Challenges and Strategies for Better Quality of Life

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ABSTRACT: Water is a prime natural resource, a basic human need and a precious national asset. Safe potable water, improved housing and clean environment are vital elements in transformation of life. It has been estimated that the water consumption will continuously rise due to over population and industrialization. The fresh water demand for agriculture, industry and fast growing urban centers are expected to be double by 2025. Skilful management of our water bodies is required if they are to be recreation, power generation, flood protection and waste disposal. Water is the most precious gift of nature to mankind. The water pollution is primarily associated with microbial contamination or due to chemical contaminants affecting physico-chemical characteristics of water. According to World Health Organization (WHO) 80% disease are water borne. The microbial contamination is due to poor or damaged pipeline, sewage discharge, defecation seepage and poor person hygiene practices. The water gets contaminated with different viruses, bacteria, protozoa, fungi, algae and helminthes. The discharge of effluents, sewage treatment plants, drains and indiscriminate disposal of wastes from factories adversely effect the situation. The effluents are complex mixtures of a large number of variable harmful agents. The water quality may be affected due to contamination arising from natural or man made sources. High concentration of fluoride, salinity and arsenic in certain pockets may be due to geologic origin. The increasing concentration of Heavy Metals, Pesticide residues, Phthalic Acid Esters (PAEs), Polycyclic Aromatic Hydrocarbons (PAH), fertilizers etc. are a matter of concern. The modern bio-monitoring or sensor/probe based technologies are focused on early detection, reduction or removal of environmental contaminants. Supply of safe water inadequate quantities has been recognized as the basic need in several programmes of the National and International agencies. In association with water quality surveillance the sanitation facilities and personal hygiene practices must be interlinked for better results. The decline in the environmental quality as a consequence of pollution is evident by loss of vegetative cover and reduction in biological diversity. Excessive concentration of harmful chemicals in food chain, ambient atmosphere, growing risk of environmental accidents and threat to life support system is anticipated to be a great problem improving proper pipe supply and storage with adequate treatment of available water sources. The appropriate state of art technologies such as bio-sensors and nano-techniques must be implemented during monitoring, water treatment and distribution for better quality of life. The water quality should be monitored periodically as per national and international guidelines/specifications (IS 10500: IS 13428: IS 14543: IS 3025: WHO Guidelines). The public partnership and motivation among the masses for water conservation, water harvesting and water management in a cost effective manner must be encouraged. The traditional knowledge of water purification may be implemented including new innovations.

INTRODUCTION

Water is a common chemical substance that is essential to all known forms of life. Water is the essence of life. The quality and quantity of water is essential for survival of life and industrial growth. Access to safe drinking-water is vital for healthy life, also basic human right and accordingly considered as component of all holistic plans throughout the globe for health protection. The importance of water, sanitation and hygiene for health and development has been reflected in the outcomes of a series of International policy forums and environment related protocols.

The rapid strides in technology and unprecedented population growth have depleted the earth's water resources with respect to quality and quantity. Due to shortage of potable water it is an issue of great concern for the sustainable development of the current population. According to World forum report (Kyoto Protocol, 2003) only 0.3 percent of the earth's total water supply is usable by humans. The world has reached the brink of water crisis, especially in developing countries and large sections of population are forced to consume polluted water. About two million tons of wastes dumps everyday in the fresh water lakes, rivers and streams polluting them for years. It has been estimated that about 80% diseases are water borne (WHO, 2006) and nearly 2.2 million people die each year as a result of consuming contaminated drinking water (Arbuckle, T.E. *et al.*, 2002). Diseases related to contamination of drinking-water constitute a major burden on human health.

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Interventions to improve the quality of drinking-water provide significant benefits to health. The concentration of impurities/toxicants may vary from region to region depending on variable factors. The guidelines for water have been set by the International/National regulatory agencies but it is experienced that there is a gap between the guidelines and the implementation in day to day life. The guidelines are updated from time to time in order to include the state of art, knowledge, improvements in monitoring and management in global perspective, distribution in context of national, environmental, social, economic and cultural conditions.

The pollutants in water may be soluble or insoluble depending on the specific characteristics (De, A.K. 1995). Water soluble impurities may be toxic which include Persistent Organic Pollutants (POPs) viz. pesticides, polycyclic aromatic hydrocarbons, Phthalic Acid Esters (PAE's) etc.; inorganic ions like nitrates, fluoride, arsenic; heavy metals like mercury, lead and chromium. Bacteriological contamination may or may not persist along with microscopic pathogens like viruses, bacteria, fungi etc. Source of water pollution may be both, anthropogenic and non-anthropogenic. Anthropogenic sources like untreated sewage water discharge, industrial effluents, runoff from farms, acid rain, leachates from landfills (included in point sources) and other sources of non point pollution contaminate ground water and surface water. In few areas, geochemical contaminants viz. nitrate, arsenic, fluoride, iron etc. may be naturally available in aquifers.

Water challenges are also related to increasing energy demands, global climatic change, new metabolites of chemicals due to industrialization, and reasons beyond explanation. The distribution and supply system in few countries is very old and regular maintenance, upkeeping and change is expensive and time consuming (Zierolf, M. *et al.,* 1996). It is praiseworthy that new S&T advancement through R&D, continual improvement programmes have led to the fabrication of technologies in the area of water quality analysis, monitoring, development of appropriate technologies for decontamination and waste water treatment. Globally the efforts are being taken for adoption of the well proven and cost effective technologies for water quality management. The water disinfection devices are now frequently used by the great number of population who are aware with the latest knowledge of health implications due to consumption of unsafe water. Surface and ground water storage, desalination, water reuse, weather modification, ground water recharge and conjunctive use are some important issues which are becoming essential for growth of human civilization and industrialization. Water conservation, remedial measures to combat environmental pollution, recycling and adoption of latest technologies may be effective to establish equilibrium between supply and demand.

GUIDELINES FOR WATER QUALITY

The Bureau of Indian Standards, World Health Organization, Environmental Protection Agency and other International bodies have given several definitions for safe drinking-water and has set the guidelines/specifications (IS 10500: IS 13428: IS 14543: IS 3025, WHO 2006, EPA 2007). Potable water is expected to not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. The guidelines are intended to support the development and implementation of risk management strategies that will ensure the safety of drinking-water supplies through the control of hazardous constituents of water. These strategies may include national or regional standards developed from the scientific basis provided in the Guidelines. Governments usually dictate the standards for drinking water quality. These standards will require minimum/ maximum set points of contaminants and the inclusion of control elements that produce potable drinking water (Vanloon, W.M. *et al.,* 1996). Amongst the criteria, guidelines have been established for the following:

- Physical properties of temperature, color, odor and turbidity;
- for general chemical classes of chemical properties such as pH Total Dissolved Solids (TSS), salinity, hardness, Biological Oxygen Demand (BOD), detergents, and petroleum residues;
- for specific elements, complex ions, organic compounds and radiological properties; and
- for microbiological properties, i.e., counts of specific organisms and groups of organisms.

Some important tolerable limits according to Indian Standard IS 10500 for safe potable water are illustrated in Table 1.

WATER QUALITY MONITORING FOR PAE'S

Phthalic Acid Esters (PAE's) or Phthalates are Semi Volatile Organic Compounds (SVOCs) which are widely used as plastic additive for the plastic industry to provide plasticity to plastic and polymeric products (Rahman, M. *et al.,* 2004). The aquatic environment may be contaminated through leaching or migration of different industrial chemicals or effluents containing phthalates inadvertently in lower concentration (Serôdio, P. *et al.*, 2006). In addition, several industrial plant produce large amount of waste water containing a reasonable concentration of phthalates which have negative effect on the aquatic environment. Phthalates-Di-Ethyl Phthalate (DEP), Di-Butyl Phthalate (DBP), and di (2-ethylhexyl) Phthalate (DEHP) may be present in variable concentrations due to their extensive applications and unregulated disposal. Phthalates in large concentration are considered to cause adverse health effects in humans and wildlife. Di-(2-ethylhexyl) phthalate and di-n-butyl phthalate show the great potency of reproductive toxicants. MRL and NOAEL (No-Observed-Adverse-Effect-Level) For DEHP and DBP are 0.1 mg/kg/day, 0.5 mg/kg/day and 14 mg/kg/day, 50 mg/kg/day respectively (ATSDR, 2006). The recommended level of DEHP and DBP in water is 6 μg/l and 34,000 μg/l (EPA, 2001).

Table 1: Indian Standard Specifications for Drinking Water (IS: 10500)

Sl. No.	*Parameter*	*Requirement Desirable Limit*
1.	pH	6.5–8.5
2.	Total Dissolved Solids (TDS) in mg/l	500
3.	Total Hardness (mg/l)	300
4.	Chloride (mg/l)	250
5.	Fluoride (mg/l)	1.0
6.	Nitrate (mg/l)	450
7.	Sulphate (mg/l)	200
8.	Cyanide (mg/l)	0.05
9.	Total Alkalinity (mg/l)	200
10.	Arsenic (mg/l)	0.01
11.	Mercury (mg/l)	0.001
12.	Cadmium (mg/l)	0.01
13.	Lead (mg/l)	0.05
14.	Iron (mg/l)	0.3
15.	Manganese (mg/l)	0.1
16.	Chromium as Cr^{6+} (mg/l)	0.05
17.	Copper (mg/l)	0.05
18.	Zinc (mg/l)	5.0
19.	Pesticide	absent
20.	Total Coliform Bacteria	95% of samples should not contain coliform in 100 ml 10 coliform/ 100 ml
21.	E. coliform Bacteria	Nil/100 ml

It was observed that the groundwater is comparatively much more contaminated in comparison to tap and surface water. The reason may be due to dumping of waste containing plastic products or landfilling of waste products or co-disposed near water resources. Phthalic acid esters are not chemically bound, but only physically bound to the plastic structure (Domininghaus, H. *et al.*, 1988). The possible source may be linked to leaching or migration of phthalates through direct or indirect modes in the variable environmental matrices as well as degradation of polymeric products (Bauer, M.J. 1998 and Bosnir, J. 2003). Phthalates are well known endocrine disruptors and there is a need to find substitutes which are ecofriendly, cost-effective and degradable with no adverse implications on environment and human health.

WATER ANALYSIS AND PURIFICATION TECHNIQUES

Water crisis is not feared because of water shortage on earth surface, but for the non-availability of efficient and cost effective water purification technologies. The water analysis kit(s)/, analyzers and monitoring equipments have been designed, fabricated and upgraded by the several national and International organizations/ corporate/NGO's/Industrialists for reaching to the greater sector of the population. Water purification is the process of removing contaminants from a raw water source (Ronald, N.K. *et al.*, 2008). The goal is to produce water for a specific purpose with a treatment profile designed to limit the inclusion of specific materials; most water is purified for human consumption (drinking water). Water purification may also be designed for a variety of other purposes, including meeting the requirements of medical, pharmacology, chemical and industrial applications. A water purifier has to deal with physical, chemical and biological adulterants including dissolved solids, heavy metals and pesticides. Besides, all contaminants have different characteristics like molecular weight and size, water solubility, volatility and ability to react with oxygen. Hence, water treatment is a multi-pronged process, and the contaminant challenge has a big say in selecting appropriate technology. Eight different methods are commonly used to purify water. These are distillation, deionization, reverse osmosis, activated carbon filtration, microporous filtration, ultrafiltration, ultraviolet oxidation and electrodialysis (Jiuhui, Q.U. 2008). The water purification devices of different organizations are available in the market but still the efforts are needed for appropriate technologies at minimum/affordable cost for the masses. The effectiveness of few purification systems is compared in Table 2.

Table 2: Water Purification Process Comparison

System Performance Comparison*	Distillation	Deionization	Carbon Filtration/ Activated Carbon	Reverse Osmosis (R.O.)	Micro Porous Filtration	Ultrafilt ration	U.V. Oxidation	6-Stage R.O. System with U.V.
Microbiological	√	×	×	√	√	⊕	√	√
Pyrogens	√	×	×	√	⊕	×	×	√
Particulates/ Dissolved Solids	√	√	×	×	√	×	×	√
Dissolved Organics	⊕	×	√	⊕	⊕	√	√	√
Inorganic Impurities	⊕	×	⊕	√	⊕	×	⊕	√
Heavy Metals	×	×	√	√	⊕	×	⊕	√
Radioactive materials	×	×	×	⊕	×	×	×	⊕

*New technologies are being designed, fabricated and upgraded periodically, as such it is representative
√ = Excellent (capable of complete or near total removal)
⊕ = Partial (capable of removing good percentages)
× = Poor (little or no removal).

The desired steps for safe guarding water quality and environmental awareness are as ut infra:

1. Strict rules and regulations should be formed and implemented in order to preserve water.
2. Latest techniques and strategies may be used for water quality monitoring and decontamination.
3. Motivate the masses to participate in water conservation, water harvesting and effective water management.
4. Mutual trust should be built up between stakeholders, policy makers, regulatory authorities, R&D institutions, NGO's, schools & colleges and common masses etc.'
5. Traditional knowledge of water purification and water harvesting may be implemented including new innovations.

CONCLUSIONS

There is a need for development of easily available and cost effective technologies for water of the quality as per specifications of BIS/WHO/EPA. The water quality monitoring should be a regular feature and it requires co-ordinated efforts from multi disciplinary fields of expertise ranging from R&D, regulatory to management and marketing. The efforts are also needed for decontamination of toxic pollutants to safeguard human health and adverse implications on bio diversity.

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