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# Operational Procedures and Reliability for Safe Drinking Water

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Polluted water is affecting not only biodiversity but also the public health severely [1]. People in the developing countries are deprived of safe drinking water due to lack of awareness about personal hygiene. Thus, immediate intervention is required at the level of water supply before public distribution, or at household level. WHO recommends water sanitation and hygiene (WASH), is critical in achieving health [2] under programme Millennium Development Goals (MDG) up to 2015 for sustainable access to safe drinking water. According to a WHO 2007 report, around 1.1 billion people are lacking availability of safe drinking water and more than 400 children are dying every year owing to waterborne diseases. According to WHO reports, death of 1.6 million children is due to diarrhea under the age of 5 years [3].Various neurological diseases also have been reported along with the malnutrition and arthritis because of waterborne pathogens. Government is investing huge resources in providing clean water to public. There are various causes which are responsible for poor water supply in public system such as poor distribution system, poor maintenance of water pipe and ineffective sanitization technique in overall making safe drinking water [4]. Drinking water reliability is much in doubt today because of presence of various dangerous pathogens also [5] and thus needs urgent attention against various waterborne pathogens and some heavy metal contaminants present. The most severely effects had been observed in many developing countries such as Bangladesh [6], India [7] and China [8]. In India, specially in Assam rural area, water supply from well is reported to be contaminated with heavy metals [9], while in Rajasthan water is contaminated with pesticide [10], contamination of Fluoride in Haryana [11], and water is contaminated with Arsenic contamination in west Bengal [12] and recently, there is additional report of pharmaceutical contamination in drinking water [13]. According to Fawell [14], every country must follow strict guidelines issued by WHO, in order to supply safe drinking water, under safe limit. Many survey and reports shows [15] that despite of various guidelines, only few country has been successful in providing safe drinking water to >50% population. According to the Global Annual Assessment of Sanitation and Drinking-Water [16,17], around 2.5 billion people were living without access to improved sanitation facilities and 770 million people in 2011, were not receiving safe drinking water.

Even today, various pilot scale measures and programme previously launched by WHO in many regions of world, for improving potable water is inadequate in ensuring safe water supply as still many reports of poor sanitation and health problems specially in developing and poor countries are existing at alarming level. As a result water itself is becoming a threat for life of children, women and aged people. To combat this situation, water treatment at the household level has been suggested in order to safe water. Adapting some technology at household level is found to be not only one of the most effective way of getting rid of waterborne pathogens and also proved to be very cost-effective. Thus, promoting household water treatment and safe storage (HWTS) is recently WHO-sponsored programme for Millennium Development Goals for achieving water and sanitation targets. These programs not only proved to be highly successful in lowering down the overall cost of investment against healthcare but also increased the productivity and income of the family and also helped in improving overall school attendance of the students [18].

Various causes are reported behind contaminated drinking water such as mixing of polluted water bodies in public water supply system [10,19] or contamination of microbes [20], or radiological effects [21] via various heavy metals such as uranium or arsenic [22]. Arsenic has been reported to pose a bad health impact in form of skin lesions and even cancer due to high concentration up to 3400 μg/L [23].

Generally, water purification follows some simple steps 1- water pretreatment along with some 2-chlorination steps for the purpose of removing large particles present in drinking water, to minimize microbial growth, then pH is adjusted to neutrality, 3-while coagulation and flocculation is done in order to minimize the turbidity of water. Finally water is 4-filtered to remove suspended particles. Various types of filters have been in use keeping in mind efficiency and cost such as slow sand filters and membrane filters.

Currently various low cost disinfection methods is reported to be very effective such as Solar Water Disinfection system (SODIS), bleaching additions, ultraviolet, ozonization and most popular chlorination methods but alone none of the technique is very reliable in achieving safe water. Thus, combination of these found to be very effective for instance, Islam et al. [24] developed a unique combination of chemicals containing alum potash, bleaching powder and lime to purify water at point of use and experimented successfully at pilot scale in Bangladesh rural community of 15 villages on 420 people in aim to convert water into pyrogen free water. In another study by Crump et al. [25], only flocculent chemical, sodium hypochlorite was used successfully to clean water to minimize prevailing cases of diarrhoea due to very high concentration of *Escherichia coli* (turbidity 100-1000 nephelometric turbidity units NTU) in rural western Kenya. UNICEF recommended HWTS in such areas where boiling, chlorination and filtering is very effective against various diseases like cholera, enteric fever, dysentery and Hepatitis [26]. Some recommendations are also there such as point of use (POU) for a viable option to mass supply of water in public distribution system. Boiling of water by use of solar, UV or heat energy called also as SODIS treatment [26] along with use of combined coagulant such as chlorine, alum and other antibacterial material, porous ceramic e.g. fired clay and use of biosand filter have also been adapted for effective disinfection of water. Effectiveness indicator for HW chlorination is only 29% [27], while for SODIS treatment is only 26-37%, while coagulation is the most effective one range upto 45%, but this has a limitation that water must be decanted properly while for SODIS treatment PET bottle is must. Clasen et al,

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recommended use of ceramic candle, gravity filter, iodine resin gravity filter or iodine resin faucet mounted filter [15] for household-based water treatment. Out of three, iodine resin faucet mounted filter was reported to be most effective for filtration.

HWT technology is not only effective in reducing the risk of waterborne disease but is also safer for water transport, or for storage at the home [28]. The World Health Organization (WHO) also endorses HWT for many poor countries lacking appropriate facility in providing safe water at mass levels [18,29].

At household level many families judge the water as safe via presence of suspended solids, color, odor, and taste [30]. In this regard a survey for HWT applications at 67 nations concluded that around 33.0% of the households (1.1 billion people) are practicing these techniques at home successfully. Western Pacific area was reported to have highest HWT practice in this regard (66.8%) and Southeast Asia around (45.4%) while Eastern Mediterranean has low HWT practice (13.6%) and Africa was lowest (18.2%). Boiling was the most simplest, dominant and effective method under HWT practice with 21.0% adapting this method [30] (Tables 1 and 2).

Application of some chemical bleach such as sodium hypochlorite solution, the dichloroisocyanurate (NaDCC) tablets was found to be effective in disinfection of house hold water. Chlorine was reported to be highest in use and most effective at scale level at doses of only few mg/l and for 30 minutes for water treatment, where free chlorine reported to inactivate more than 99.99% of enteric pathogens reducing chances of diarrhoeal diseases except those of resistant microbes such as Cryptosporidium and Mycobacterium species [31]. Recently, a low cost and very promising technique have been developed in the form of locally-fabricated silver coated ceramics for effective house hold tool for water treatment [32]. Some other filters such as slow-sand filters are reported to be very effective in removing microbes and suspended solids by means of a forming a slime layer that entraps and removes 99% or more of enteric pathogens [33]. A more simpler filter developed said to be "bio-sand" filter, is more proved and found to be suitable for household applications [26] and has been developed by the Center for Alternative Water and Sanitation Technologies (www.cawst.org).

Sodis system, developed by the Swiss Federal Institute for Environmental Science and Technology (http://www.sodis.ch) is found to be more economical and effective in reducing, diarrhoeal morbidity, against enteric pathogens and cholera [28,34].

| Metal | Agents | References |
|---|---|---|
| As III Bioremediation | Bacteria, *Sporosarcina, Ginsengisolicrs.* Conc upto 50 mM As | [35] |
| | *E. crassipes* 600 mg As/ Ha +*lemna minor* | |
| Heavy metals | Banana and orange peel 5-25 mg/l $Pb>Ni^{2+}$ | [36] |
| Complete water purification including microbial decontamination | Ultrapurification | [27] |
| As (III) | *Stenotrophomonas* sp. MM-7(8.8 mg/kg) via arsenite oxidase | [37] |
| As(III) | Arsenic resistant microbe belongs to proteobacterium Conc. 100 mM Others metals also purified like Ni, Zn,Cu, Pb, Co | [38] |
| Fe+3 | Electrocogulation 25 mg/L | [39] |
| As(III)+ microbial decontamination | Carbon nanotube $10^7$ CFU/ml | [40] |

**Table 1:** Some Reliable water decontamination methods.

| Water treatment Method | Cost/person/year |
|---|---|
| 1. Solar Disinfection | US$0,63 |
| 2. Chlorination | US$0.66 |
| 3. Ceramic Filters | US$3.03 |
| 4. Combined Flocculation/Disinfection | US$4.95 |
| 5. Installing & Maintaining Wells, borehole and Communal Tap Stands in Africa | US$1.88 |

**Table 2:** Various promising water treatment methods and the cost recurring per person per year [15].

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