American-Eurasian J. Agric. & Environ. Sci., 3 (2): 241-246, 2008
ISSN 1818-6769

Household Water Management: A Systematic Study of Bacteriological Contamination Between Source and Point-of-use

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Abstract: To evaluate the extent and causes of bacteriological contamination of household drinking water between source and point-of-use, 101 family's water (before and after use) were examined for its potability and correlated it with water collection, storage and handling practices. Faecal contamination levels in household water containers were generally high even when the source water was of good quality. Studies indicated that practices of water collection, storage, handling and the choice of storage containers or vessels, hygiene education, number of children, socio-cultural status significantly affect the quality of drinking water in the houses and improvements in behavioral and water hygiene practices can improved the household water quality.

Key words: Household water · contamination · coliform · water microbiology · drinking water quality

INTRODUCTION

Over a billion people in India lack safe water, 80% of infectious diseases are water borne, killing millions of children each year. Several parts of India are facing an immense challenge to meet the basic needs of safe water. There arises an urgent need for understanding the status of drinking water quality, the related problems and also the reason of the problems [1]. This understanding will help those people, most affected by water quality problems to evaluate and change the situation. To change the situation, the importance of education, socio -cultural acceptance, changing people's beliefs and behaviors achieved sustainability and affordability in the provision of safe water. Provision of safe household water included the conditions and practices of water collection, storage, handling and the choice of storage containers or vessels [2]. Water may become contaminated at any point between collection, storage, serving or handling in houses [3]. Microbial contamination of collected and stored household water is caused not only by the collection and use but unsanitary and inadequately protected (open, uncovered or poorly covered) water collection and storage containers. Unsanitary methods to dispense water from household storage vessels, including contaminated hands and dippers and inadequate cleaning of vessels, which lead to accumulation of sediments and pathogens [4]. Water becomes contaminated by incorrect method of collection, storage, serving and handling practices and improving water-handling practices by promoting water hygiene behavior improved water quality. The personal and domestic hygienic practices indirectly depend on the education of the family members, water hygiene education, socio-cultural status, number of children in the house etc [5-7].

Unsanitary methods to dispense water from household storage vessels, including contaminated hands and dippers and inadequate cleaning of vessels, which lead to accumulation of sediments and pathogens [8-10]. Thus it indicated that improper storage, handling and serving practices usually contaminate the drinking water in houses thus attempt was made to find out the water hygiene practices and behaviors in houses and their effect on the bacteriological quality of drinking water.

MATERIALS AND METHODS

The study was conducted to observe the effect of handling and personal hygienic practices along with the education and socio-cultural status etc of families' houses on the quality of drinking water after storage in the container. For the study, randomly 101 families

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with various socio-cultural and economic status were identified from the various places of Amravati city and water sample before and after used were collected along with family data as per prepared questionnaires from respective houses between July to December, 2006. A total of 202 drinking water samples were collected from 101 families, two water samples from each family (before and after use), from storage container/ vessel of the house. The bacteriological examination was performed within the 24 h of collection using standard Multiple Tube Fermentation Technique (MTFT) for determination of Most Probable number (MPN) index of total coliform (Tc); a nine multiple tube dilution technique using double and single strength Bromo-Cresol Purple MacConkey medium. The MPN Index was calculated from MPN table and index of water more than 10 coliforms/dl is designated as polluted or unhealthy for drinking purpose or non-potable [11].

The family data were collected using interview and observation methods. In the interview, information on education of house owner and his wife, number of children, income of family, method of collection and storage of water, water-handling practices etc. were collected from households from where water samples were collected for analysis. Collected data was statistically analyzed by using SPSS software (SPSS version 15.0 for window) in relation to potability of drinking water.

RESULTS AND DISCUSSION

Microbiological contamination of water between source and point-of-use is widespread and often significant. Increased faecal and total coliform counts in household stored water container are generally high even when the source water is of good quality, suggesting that contamination is widespread during collection, transport, storage and drawing of water [12]. Water must be stored and drawn in a safe manner otherwise the water can be re-contaminated. The latter often happens when there is a communal drinking cup or dipper on top of the covered storage vessel. When wanting a drink, adults and children in the family dip this dipper into the water and may then touch the water with soiled hands, e.g. from anal cleansing. In this way, bacteriological quality of drinking water significantly decline after collection and water quality deterioration occurred between the point of supply and consumption [13].

To find out the probable cause of the contamination in drinking water this survey was conducted and quality household drinking water (before and after use) were analysed for coliform contamination. A total of 202 water samples (two water samples from each family, before and after use) from 101 families were collected and analysed for potability of the drinking water. Out of 101 water samples collected before use, 64 potable and 37 were non-potable. Out of 101 water samples collected after the use, 89 were non-potable and 12 potable. Out of 64 family's water (potable before use), 52 became non-potable after use and 12 remain potable. All 37 non-potable water samples remain non-potable after use (Table 1). Out of these 12 families (water remain potable after use), 11 (22%) were Hindu and 1 (8%) Muslim. Out of 52 families (water became non-potable after use), 40 (78%) were Hindu and 12 (92%) Muslim. Socio-cultural status of the family also affects the quality of the drinking water [14, 15]. It is been observed that socio-cultural poor families (very poor and poor), (0% potability of water after use, PWAU) and high class families (14% PWAU) (servants looking after the kitchen and most of them are illiterate) could not maintained the water free from faecal contamination as compared to middle class family (29% PWAU) who themselves collecting and storing of water and kept the maximally free from contamination. Hand washing is essential step to reduce many water borne or water related communicable diseases, families wash their hand before taking water had less contamination than those who don't or some times washed their hands. The data showed that washing of hands (53% PWAU) before collecting or withdrawing water reduced the chances of contamination. Handwashing practices in household reduced the incidences of diarrhoea among children, as children take water themselves after playing without handwashing or by dirty hands, which enhances the chances of water contaminations [9, 16]. Families maintaining overall good hygienic conditions in the house maintain the good (24% PWAU) quality of water (Fig. 1) and maintains hygienic conditions in the houses, which have prominent role on the quality of water [17].

Table 1: Potability of household drinking water

Potability before use		Potability after use	
Potability	Total	Non-potable	Potable
Non-potable	37	37	0
Potable	64	52	12
Total	101	89	12

The number of family members, number of children, education and their hygienic practice play an important role on the quality of drinking water [18, 2]. It is been observed that more the number of members or children

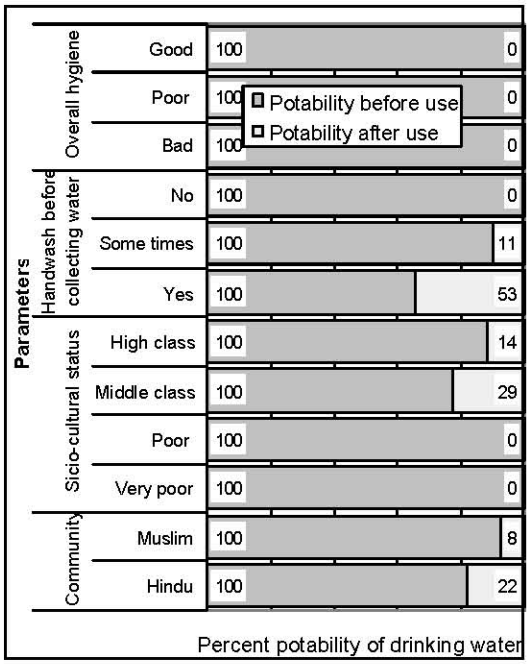

Fig. 1: Effect of community, socio-cultural status, handwashing and overall hygiene on the quality of drinking water

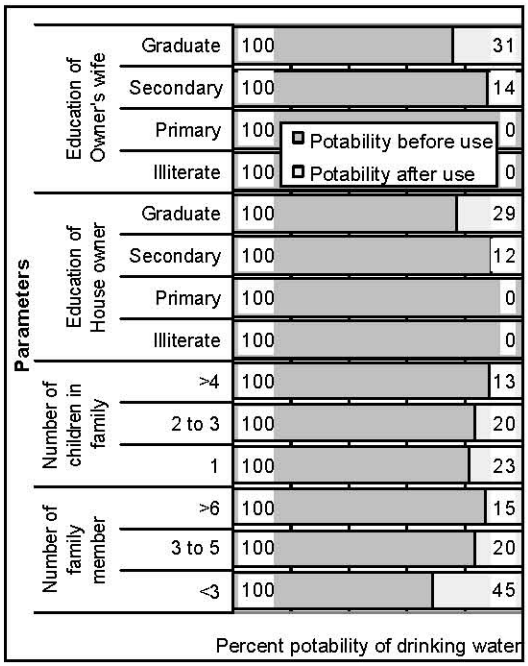

Fig. 2: Effect of number of family members and children, education of house owner and his wife on the quality of drinking water

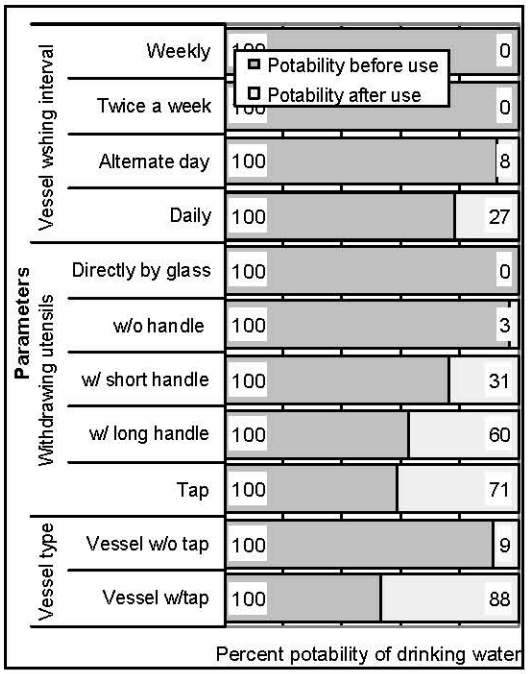

Fig. 3: Effect of vessel type, dispensing methods, washing intervals of vessels on the quality of drinking water

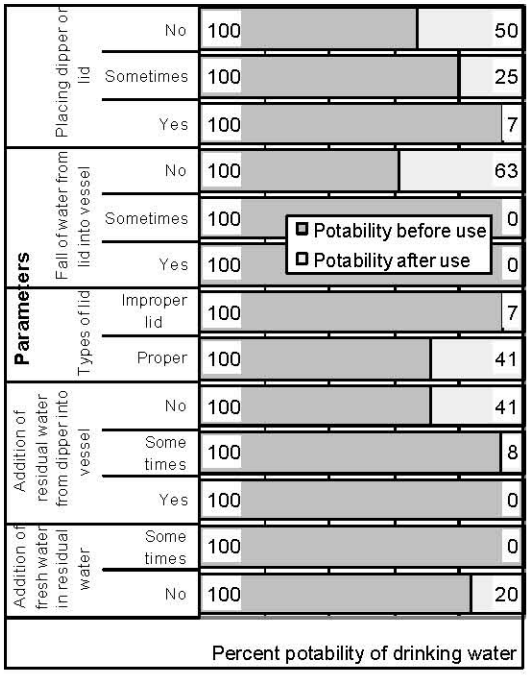

Fig. 4: Effect of addition of fresh water in residual water or residual water from dipper into vessel, types of lid, fall of water from lid and placing dipper on lid on the quality of drinking water

per family higher the degree of contamination in stored drinking water. It may be due to large handling of the same storage water by large number of family members and children. Children may, in particular, cause contamination when they put their faecally contaminated hands or utensils into the house hold water container. Out of 64 families (potable water before use), 29%, 12% and 0.0% house owner, who maintain the water potable were graduated, SSC and primary or illiterate respectively. At the same time, 31%, 14% and 0.0% family's water remain potable water after use, where house owner's wife education was graduate, SSC or primary/ illiterate respectively. It is indicated that educated middle class family members stored and handle the drinking water maximally safe and kept free from contamination (Fig. 2).

The types of container affect the keeping quality of household drinking water [19]. Families, which used the containers with tap, maintain the potability of water upto 88% and families using container without tap reduced the water quality to 9% indicating that no contact of hands with water prevent the contamination in water. The withdrawing utensils may be one of the causes of contamination of drinking water as there are chances of water contamination with fingers or dirty dipper or glass while withdrawing the water [20]. Families using tap (71% PWAU), or dipper with long handle (60% PWAU), or dipper with short handle (31% PWAU) for withdrawal of drinking water reduced the contamination as compared with utensil without handle (3% PWAU) and directly by glass (0% PWAU), indicated that prevention of contact of hands or fingers with water by using long or short handle dipper or tap reduced the transmission of contamination in the stored water. Washing interval of water storage container also affects the quality of water and it was 27% in daily washing, 8% in alternate washing and 0% in twice or once per week washing (Fig. 3). The daily or alternate day washing prevent the biofilms formation and contaminations of water. Additions of fresh water in container containing residual water or residual water of dipper or jar or glass in to storage container enhance the chances of contamination. Proper lid (41% PWAU) on the containers, avoiding fall of water from lid into container (63% PWAU) and keeping dipper on lid prevent the contamination in household stored water (Fig. 4).

The study indicated that water quality deterioration occurs as a result of multiple factors linked to hygiene practices and circumstances. Never the less, only hands and water drawing utensil are involved at every stage of domestic water managements and can directly contaminate stored drinking water through contact, or indirectly through the transfer of faecal material to containers used in household water storage. Analysis of sub-groups, such as specific types of practices, the point at which it is applied (e.g. point of supply *vs.* point of use) and whether or not the practices includes components in addition to improved water quality (e.g. proper sanitation, hygiene promotion, safe storage) may also be important. The domestic pathways of pathogen contamination of household drinking water are independents of pollution at the source. Although, the bacteriological water quality improved, elimination of direct hand contact with stored water inside the household only could not prevent the occasional occurrence have extend pollution of the drinking water at its source.

The study recommended that container with tap, long or short handle dipper used for withdrawal of water from storage container, proper lid, daily washing of container, avoid addition of fresh water in residual water or residual water from dipper into stored water are few remedies to control transmissions of contamination in water and prevention of enteric infection in the families. The education of the housewife also affects the storage, handling and hygienic practices of drinking water. The educated housewives stored water more hygienically as they were more conscious about health as compared to non-educated housewives. Socio-cultural and economic status also affects the hygienic conditions maintained by family and indirectly affects the quality of water storage. At the same time more the family member or children, poor the quality of water as every body may not used proper hygienic procedures or wash their hands or dipper before withdrawing the water. Thus, the study indicated that the storage and handling practices, number family members, children in the family and their hygienic practices significantly affect quality of drinking water in the houses and improvements in behavioral and water hygiene practices can improved the household water quality.

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