SUMMARY SHEET

Title of the project	:	Testing, Development and Awareness Generation of Water Purification in Municipal Schools
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EXECUTIVE SUMMARY

Water quality assessment is an important part of overall water management and an essential feature in controlling spread of water borne diseases. Control on water quality is invariably nonexistent in rural areas where water is drawn from underground aquifers. With this background, an exploratory study was conducted in selected schools and villages of District Raigad, Maharashtra to ascertain problems related to drinking water and physical, chemical and microbial quality in order to recommend best purification technology for it. Three schools (Sri. Annabhau Shastrabudhe Anudanit Ashramshala, Shantivan, Wakadi, Waje High School, Waze, Nere High School, Nere) and three villages (Usurli, Chinchovli and Vangani) were selected in Panvel, Raigad (M. S.). A focused group discussion and survey was conducted to ascertain the problems related to drinking water as well as common sources of drinking water and water borne diseases.

Drinking water samples were collected in all the three seasons (Pre monsoon, monsoon and post monsoon) as per standard method from sources viz. bore well, hand pumps, well etc. Samples were analyzed for physical (pH, turbidity, electrical conductivity, total dissolved solids), chemical (alkalinity, hardness, chloride, sulphate, nitrate) parameters. Microbial analysis of all the samples was carried out by Multiple Tube Fermentation Method and the results were summarized in terms of MPN index. IMViC, that is a biochemical and enzymatic analytical technique was performed to identify major pathogenic bacteria. Low cost disinfection techniques viz. boiling, chlorination and solar disinfection (SODIS) of infected samples was carried out to evaluate their effect in all the three seasons.

Sources of drinking water were observed to be from only underground water drawn by bore well, hand pump or open well. The physical and chemical parameters of water samples were found to be within the prescribed limits. Samples showed minor variations in physical, chemical and microbial contamination levels with season though salinity problems were not encountered. Around 40 to 80% of the drinking water samples are found to have microbial contamination. In monsoon, microbial contamination was highest. Most of the collected water samples were found to be contaminated with *E. coli* and *Klebsiella*, hence were unfit for consumption. SODIS proved to be an effective and economical method for disinfection.

Five awareness generation programmes were performed in selected schools and villages to impart knowledge about the common sources of pollution in drinking water, diseases and low cost purification techniques of drinking water. NGOs working in selected areas were involved to ensure impregnation of knowledge for long run. Training materials viz. posters, pamphlets and audio- visual aids in regional language Marathi were prepared and distributed to make training programmes interesting and easy in learning technical aspect of water purification. In order to assess the impact of awareness generation programmes, pre and post knowledge feedback forms were filled up by the participants. Completely filled forms were analyzed by using statistical tools to evaluate the significance of training before and after the programmes. Significant improvement in knowledge of participants was observed. Majority of villagers were found to use chlorination for disinfection of drinking water because Public Health and Engineering Department is promoting it mainly in rainy season. However, they were not sure about the standard dose of chlorine drops required for disinfection. Moreover, participants were not aware about the negative effects of excess chlorine on human being. Through our programmes we were able to successfully impart this knowledge and create interest in other low cost techniques for water purification.

Further studies on the popularization of knowledge on low cost water purification techniques for adoption are required.

BACKGROUND OF THE PROJECT

Provision of safe drinking water to the general public is one of the key objectives of Public Health Management and a number of habitations are suffering from a variety of water quality problems not only in rural India but also in metropolitan cities. Technological approaches to providing safe drinking water in the Indian context are recently reviewed by Prabhakar (2008). The drinking water quality data analysis and compilation is done by several government as well as non governmental agencies in India. Several educational institutions also had undertaken this task in the past at nearby locations. The efforts of NGO's and educational institutions had been sporadic and confined to restricted periods and such data had been useful in the past in identifying the problems of contamination. The diseases most commonly transmitted through piped drinking water are gastroenteritis, typhoid, cholera, paratyphoid, dysentery, diarrhea, polio, hepatitis and jaundice. The causative agents could be bacteria or viruses or sometimes even chemical toxicants. In recent years, in spite of advancement in water purification methods many incidences of drinking water contamination have occurred. Sur *et al.* (2007) reported an outbreak of acute viral hepatitis due to hepatitis E virus in Hyderabad from March through Aug 2005. In another study, Pathak *et al*., 2008 reported 34 % samples of drinking water to be non potable due to presence of coliforms such as *E coli*, *Klebsiella* sp. *Citrobacter* sp. and fecal *Streptococci*. Moreover, the contaminants exhibited multiple antibiotic resistance. The authors suggested that the drinking water contaminated with antibiotic resistant entero toxigenic fecal bacteria to be responsible for presence of water borne diarrheal diseases attributed to therapeutic agents used by urban population in the tropics. There are reports of transmission of Enterohemorrhagic *E. coli* from drinking water distribution systems in Lucknow. (Ram *et al*., 2008). An outbreak of typhoid fever due to waterborne transmission through piped water supply was reported from South Dum Dum area, West Bengal in 2007 Jan- Apr. (Bhunia *et al.*, 2009). In a study by Clansen *et al*., 2008, 40.4 of stored drinking water samples were positive for fecal coliforms with 25.1% exceeding 100 fc/100ml.

In a community based bacteriological study of quality of drinking water in Maharashtra 45.9% of the samples from piped water supply were polluted. Tambe *et al.*, 2008. In the Metropolitan city of Mumbai an article reports that the levels of bacterial contamination can go upto 20 % in many wards. Samples from P. L. Lokhande Marg Chembur, Masjid , Parel- Dadar , Mulund and Jogeshwari touched 1600 fc/100ml water. Some middle class housing societies in Chembur which were surrounded by slums had 70 % samples unpotable. According to NMMC environment status report 2003-04, 9.08 % of samples were contaminated with bacteria and thus unpotable. Moreover, percentage of water samples unfit for drinking was very high in summer.

The contamination is largely due to infiltration of sewage into water mains. This happens when water lines run through dirty pools of water parallel to sewage pipes or are damaged within the building compounds or streets. Poor maintenance of overhead and underground tanks is another important cause.

Jonnalagadda and Bhat (1995) have reported parasitic contaminants of stored water used for drinking and cooking in Hyderabad. They reported cysts of *Giardia lamblia*, *Entamoeba histolytica*, adult stages of *G. lamblia* , *Balantidium coli* and nematode eggs (*Enterobius vermicularis*, *Ascaris lumbricoides*, *Trichuris trichiura*) rhabditiform and filariform larvae, adult stages of *Strongyloides stercoralis* and *Enterobius vermicularis*.

Occurrence of natural calamities are known to initiate contamination of drinking water contamination. Rajendran *et al*. (2006) studied bacteriological analysis of water samples from tsunami hit coastal areas of Kanyakumari district. Presence of coliforms was detected in 56 water samples. An outbreak of rotavirus under gastroenteritis was reported post earthquake conditions in Kashmir through piped tap water (Chandra *et al*., 2008). About 6311 cases of fever and 233 deaths were reported after July 2005 flood in Mumbai and Thane districts. Apart from this, there was spread of other water borne diseases and leptospirosis

No doubt that chlorination has been successfully used for the control of water borne infectious diseases, however, identification of chlorination by products and incidences of potential health hazards created a major issue on the balancing of the toxicodynamics of the chemical species. There have been epidemiological evidences of close relationships between the exposure and adverse outcomes particularly the cancers of vital organs in human beings. Trihalomethanes and haloacetic acids are two major classes of disinfection byproducts commonly found in waters disinfected with chlorine. Rajan *et al*., 1990 reported trihalomethane levels in Chennai public drinking water supply system which are potential mutagen, carcinogen and teratogen. Boorman 1999 reviewed drinking water disinfection byproducts and reported that they were responsible for bladder, colon and rectal cancer. Bakore *et al*. (2004) reported organochlorine pesticide contamination in drinking water samples from Jaipur. In order to reduce public health risk from these toxic compounds regulations must be enforced for the implementation of guideline values to lower the allowable concentrations or exposure. (Gopal *et al*., 2007).

Sobsey *et al.* (2009) studied different point of use technologies for safe drinking water. They suggested ceramic and biosand household water filters are identifies as most effective according to the evaluation criteria applied and as having the greatest potential to become widely used and sustainable for improving household water quality. One prospective intervention study found consumers of RO filtered water had 20-35% less gastrointestinal illness than those consuming regular tap water with an excess of 14% of illness due to contaminants introduced in the distribution system.

The effect of deteriorating drinking water quality and its effect on public health is a subject matter of research and concern in thickly populated industrialized countries. Drinking water is a major source of microbial pathogens in developing regions, although poor sanitation and food sources are integral to enteric pathogen exposure. Gastrointestinal disease outcomes are also more severe, due to under-nutrition and lack of intervention strategies in these regions. Poor water quality, sanitation and hygiene account for some 1.7 million deaths a year world-wide mainly through infectious diarrhea. Nine out of 10 such deaths are in children and virtually all of the deaths are in developing countries (Ashbolt, 2004). Improving and protecting the microbial quality and reducing the infectious disease risks to consumers of collected water stored in households requires alternative or interim strategies and approaches that can be implemented effectively, quickly and affordably.Though chlorination checks microbial growth in most of the cases, the recontamination of the treated water is a major problem. A recently published work shows that infectious intestinal disease occurs in one in five people each year in England, but only a small proportion of cases is recorded by national laboratory surveillance system (Wheeler *et al*., 1999). Chemical products in drinking water have been associated with bladder and pancreatic cancer (Ward *et al*. 1995; Boorman *et al*., 1999: WHO guidelines, 1996), and also with reproductive effects (Kramer *et al*., 1996; Sawan *et al.*, 1998; Galaghar *et al.*, 1998). In communities with a high economic and public health development access to abundant and good quality water is stated as a basic right, and consumption of tap water is not seen as an important risk. In countries with good epidemiological surveillance systems, a series of waterborne outbreaks have been reported in communities with adequate established measures of water quality control. This represents a warning about the potential risks from drinking water despite the state of the art water treatment (Goldstein *et al*., 1996). In March of 1993, and because of a contaminated water supply, there was a widespread outbreak of gastrointestinal illnesses, mainly attributable to *Cryptosporidium* among the residents of Milwaukee that affected more than 400 000 people (MacKenzie *et al*., 1994). Before this outbreak there were marked increases in the turbidity of treated water, reaching a maximal daily turbidity of 1.7 nephelometric turbidity units (NTU). The major difficulties dealing with *Cryptosporidium* are that it is difficult to detect in water samples, it is very resistant to disinfection, its infective dose is low, it could affect more severely immunocompromised subpopulations, and, at present, there seems to be no effective treatment (Meinhardt *et al*., 1996; Rose, 1997). The impact of organics notably, landfill leachates, pesticides, disinfection byproducts, heavy metals, arsenic and fluoride on human health are well documented in literature (Follett and Self, 1989). Studies of the health effects of pesticides on humans focus on two aspects, the acute toxicity, or immediate effects resulting from short-term exposure, and the chronic toxicity, or effects resulting from more-prolonged exposures. Organic chemicals in water derive from the breakdown of naturally occurring organic materials, contamination of source water and reactions that take place during water treatment and distribution. A wide range of organic substances can enter the water source from human activities in the catchment. These sources include agriculture, runoff from urban settlements, wastewater discharge and leachate from contaminated soils. Most organics in water supplies that have harmful health effects are part of this group. When pesticides are found in water supplies, they normally are not present in high enough concentrations to cause acute health effects. Instead, they typically occur in trace levels, and the concern is primarily for their potential for causing chronic health problems. Although disinfection of water offers protection against waterborne infectious diseases, it also increases the risk of other diseases such as cancer due to the formation of disinfection by-products (Morris *et al*., 1992). Fluoride concentrations of 1.0 milligrams per liter or greater will reduce the incidence of dental cavities. However, concentrations over 2.0 milligrams per liter can darken tooth enamel causing fluorosis. Wright *et al*. (2004) performed a systematic review of microbiological contamination between source and point use in developing countries. They concluded that the policies to improve water quality through source improvements may be compromised by post collection contamination. They also recommended safer household storage and treatment to prevent this, together with point-of- use water quality monitoring.

Among the techniques employed in domestic water purifiers, UV sterilization is considered rapid, simple to use and economical. UV disinfection is most effective for treating a high clarity purified reverse osmosis distilled water. As a matter of facts, suspended particles are a problem because microorganisms buried within particles are shielded from the UV light and pass through the unit unaffected. However, UV systems can be coupled with a pre-filter to remove those larger organisms that would otherwise pass through the UV system unaffected. The pre-filter also clarifies the water to improve light transmittance and therefore UV dose throughout the entire water column. Another key factor of UV water treatment is the flow rate: if the flow is too high, water will pass through without enough UV exposure. If the flow is too low, heat may build up and damage the UV lamp (Gadgil, 1997). Iodine or silver impregnated resins for domestic water purification are effective, but it is difficult to know when the unit has lost its effectiveness. Exposing water to halogens such as iodine or chlorine is believed to kill bacteria and viruses, but not all protozoan cysts. Hard-shelled *Cryptosporidia* show strong resistance to iodine and chlorine. Iodized water presents a taste some people find particularly objectionable. Also Iodine can be unhealthy for some people, particularly for pregnant women, individuals with thyroid conditions. Silver can be used in the form of a silver salt, commonly silver nitrate, a colloidal suspension, or a bed of metallic silver. Electrolysis can also be used to add metallic silver to a solution. Ultrafiltration membrane based domestic water purification units claim to be very effective and economical. But its durability and reliability needed to be ascertained.

Population of Mumbai and Navi Mumbai has been increasing rapidly due to urban migration and maintaining water supply and its quality is becoming a difficult. Navi Mumbai is fast developing area in which several villages still thrive on open tanks, wells, common piped water and tanker water supply. Creating awareness about the need to maintain the water quality, water conservation methods and simple water purification techniques such as solar disinfection among the public is another major issue which requires attention. In this project we wish to undertake the water quality assessment in selected villages. Some villages beyond Panvel are identified for the study, namely, Chinchovli, Vangani, Shantivan, Waze, Bhanghar and Usurli in which seasonal variation of water quality assessment would be carried out. Study of their microbial disinfection using various available technologies was carried out in laboratory. Awareness generation among the nearby school children and villagers on the need to maintain the water quality, water conservation methods and simple water purification techniques such as solar disinfection was also conducted.

APPROVED OBJECTIVES OF PROJECT:

- To identify the water sampling locations such as open tanks, wells, common taps and tanker supplied water in the selected villages in Navi Mumbai under MMRDA jurisdiction region.

- To conduct physical, chemical and microbial analysis of the water samples collected.

- To study disinfection on the collected samples by various disinfection methods.

- To impart knowledge to the students regarding potential sources of contamination and risks associated with it.

- To create awareness about water purification and testing technologies among the nearby school children as well as among the villagers

METHODOLOGY AND SYSTEM APPROACH IN PROJECT

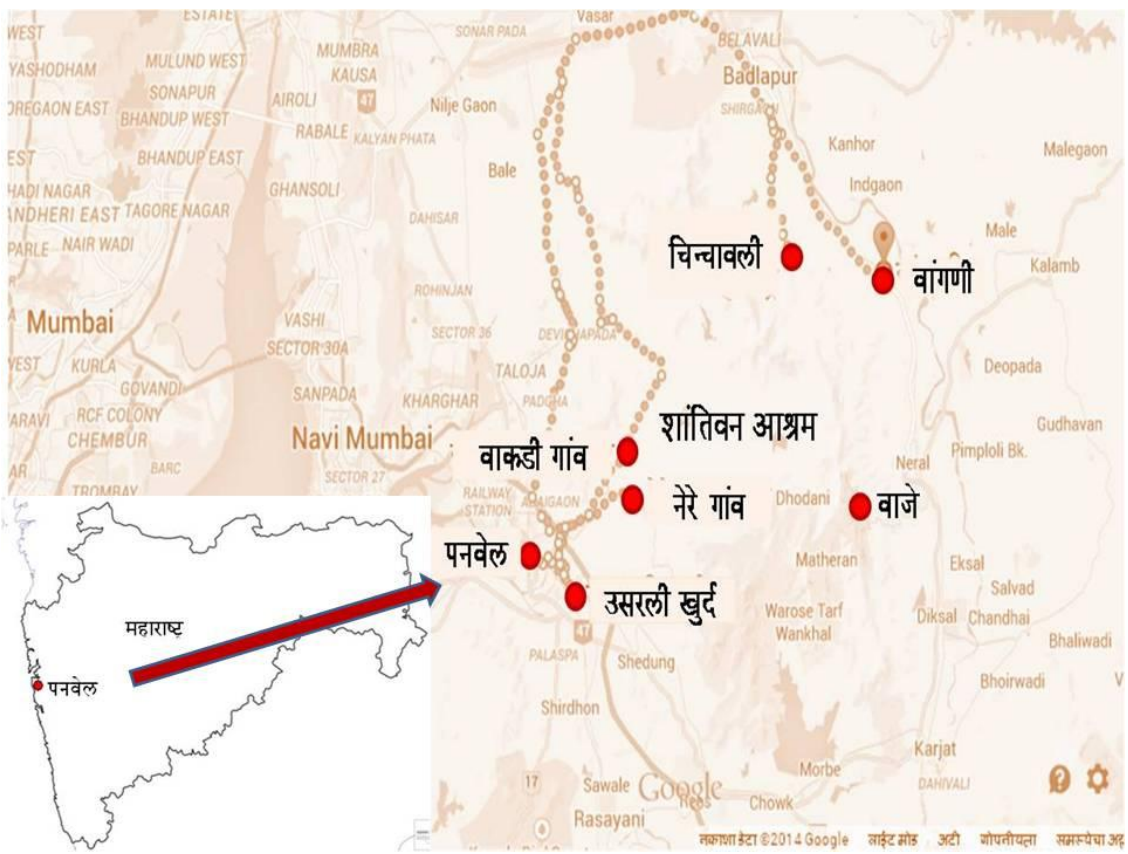
1. Survey of locations and identifying problems associated with drinking water sources and its utilization.

A survey was conducted to identify problems associated with drinking water sources, purification technique and the knowledge level of the population. It was conducted by preparing questionnaires containing closed ended and open ended questions (Annexure-I). It included 150 participants comprising both students and villagers.

2. Selection of water sampling locations

A field survey of the various villages beyond Panvel was made to identify water sampling locations. Total of 6 villages and 3 schools were identified for the study (Map 1). Details of selected villages and schools are given in Table 1.

An aerial map of sampling locations is shown below.



Map- 1: Project sites selected near Panvel, Raigad (M. S.)

Table: 1: Details of drinking water sampling locations in Panvel, Raigad (M. S.)

Sr. no	Name of the sampling location	Sources of location
Schools		
1	Sri. Annasaheb Sahastrabuddhe Anudhanit Ashramshala, Wakdi	Handpump and Well
2	Waje High School, Waje	Well and Borewell
3	Nere High School, Nere	Borewell
Villages		
4	Vangani	Handpump, borewell and stored water
5	Bhangar	Handpump
6	Usurli	Syntex tank and borewell
7	Chinchovli	Well
8	Karjat	Borewell
9	Nerul	Borewell

3. Procurement of field kits for water testing

Water testing kits required for the awareness programme under the project were procured from Development Alternatives, New Delhi. They have Jaltara kits for the analysis of water samples for physical, chemical and microbial analysis. From one kit up to 100 samples can be analyzed.

4. Sampling of drinking water samples

Three sets of drinking water samples were collected from the above mentioned locations in all the three major seasons- Post monsoon, pre monsoon and monsoon samples. Table 2 gives the number of samples collected in different seasons. The samples were transported to lab on the same day and microbial analysis samples were stored in refrigerator at 4˚C± 1˚C, however, those for chemical analysis were stored at 25˚C ± 1˚C. The sample numbers are given in Table 3.

Table 2: Details of water sampling from selected sites

Sr. No.	Seasons	Month of sample collection	No. of samples
1.	Post Monsoon	February 2014	22 (Only 15 samples were taken for final analysis because 7 samples were rejected after final site selection)
2.	Pre Monsoon	May 2014	16
3.	Monsoon	August 2014	16

Plate 1: Ashramshala at Shanthivan involved in study

Plate 2: Sampling of water sample from a bore well water collected in sintex tank located in Usurali village, Panvel

Plate 3: Project staff labeling the collected water samples

Plate 4: Sampling of water samples for microbial analysis at Vangani Village by Project staff

Plate 5: Sample of drinking water sample from a Community water supply system at Chinchovli village by project staff

Plate 6: Students drinking stored water of bore well

Table 3: Location and sample numbers at different seasons

Location and source of water	Post Monsoon sample	Pre monsoon sample	Monsoon sample
Sri. Annasaheb Sahastrabuddhe Anudhanit Prathmik, Madhyamik Ashramshala, Wakdi, Shantivan (Hand pump)	MMREIS-008	MMREIS-023	MMREIS-039
Sri. Annasaheb Sahastrabuddhe Anudhanit Prathmik, Madhyamik Ashramshala, Wakdi, Shantivan (Well water)	MMREIS-009	MMREIS-024	MMREIS-040
New English School (Bore well)	MMREIS-010	--	-
Waje School, Waje (Bore well)	MMREIS-011	MMREIS-025	MMREIS-041
Usurli (Hand pump)	MMREIS-012	MMREIS-026	MMREIS-042
Usurli (Bore well)	MMREIS-013	MMREIS-027	MMREIS-043
Usurli (Bore well)	MMREIS-014	MMREIS-028	MMREIS-044
Usurli (Bore well	MMREIS-015	MMREIS-029	MMREIS-045
Chinchovli (Bore well)	MMREIS-016	MMREIS-030	MMREIS-046
Chinchovli (Bore well)	MMREIS-017	MMREIS-031	MMREIS-047
Chinchovli (Bore well)	MMREIS-018	MMREIS-032	MMREIS-048
Vangani (Bore well)	MMREIS-019	MMREIS-033	MMREIS-049
Vangani (Bore well)	MMREIS-020	MMREIS-034	MMREIS-050
Vangani (Bore well)	MMREIS-021	MMREIS-035	MMREIS-051
Nere High School (Bore well)	MMREIS-022	MMREIS-036	MMREIS-052
Usurli Abandoned well	--	MMREIS-037	MMREIS-053
Shantivan River	--	MMREIS-038	MMREIS-054

5. Physical, Chemical and Microbial analysis of drinking water samples

The samples are analyzed for various physical chemical and microbial parameters as shown in Table 4. The results of the physical, chemical and microbial analysis of drinking water samples are given in Tables 5 to Tables 8.

The temperature of the water samples were measured at site using a glass thermometer. pH and electrical conductivity were measured using pH and Digital conductivity meters respectively. Turbidity of the samples was measured using a turbidity meter. Total dissolved solids were measured gravimetrically after total evaporation. Free CO_2 and alkalinity were estimated titrimetrically. Total hardness was estimated by EDTA titration. Cloride was estimated volumetrically by titrating using standardized silver nitrate. Sulphate was gravimetrically estimated. Fluoride was analysed using commercially procured water test kits. Dissolved oxygen was analysed using Winkler's method. Calcium, magnesium, manganese iron, copper and zinc were estimated using atomic absorption spectroscopy.

Microbial contamination in water samples were analysed by multiple tube fermentation technique and the results expressed in MPN values. Samples which showed positive microbial contamination were checked using Hydrogen sulphide gas production method.

Table 4: Physico- chemical and microbial parameters analyzed in samples

Physical parameters

Parameters	Method
Temperature	APHA, 1997
pH	APHA, 1997
Conductivity	APHA, 1997
Turbidity	APHA, 1997 (Nehphlometery)
Total dissolved solids	APHA, 1997 (By evaporation)

Chemical Parameters

Total hardness	By EDTA titration Goetz.*et.al* 1959
Alkalinity	Richard 1954
Free CO_2	By calculation
Dissolved oxygen	Winkler 1888
Chlorides	Argenometric / (Mohr's 1895) Method
Fluoride	Jaltara Kit
Nitrate	UV-Spectrophotometry (Armstrong,F.A.J 1963)
Sulphate	APHA, 1997
Calcium	APHA, 1997
Magnesium	APHA, 1997
Arsenic	By Jaltara kit
Sulphate	APHA, 1997
Copper	APHA, 1997
Zinc	APHA, 1997
Iron	APHA, 1997
Mangnese	APHA, 1997

Microbial Analysis

MPN	APHA, 1997
IMViC	Aneja, 1996
H_2S gas production	Manja et al., 1982

Table 5: Identification of microbes based on IMViC test results of contaminated water samples

Bacterial Species	Indole Test	Methyl red Test	Voges Pausker Test	Cimon Citrate Test
Escherichia .coli	+	+	-	-
Shigella sp.	+ or -	+	-	-
Citrobacter freundii	-	+	-	+
Citrobacter diversus	+	+	–	+
Klebsiella, Entrobacter & Aerobacter group	-	-	+	+

6. Disinfection Studies

Drinking water samples found positive in MPN for microbial contamination were further utilized for disinfection studies. The low cost disinfection methods viz. boiling, chlorination and solar disinfection (SODIS) were studied for identification of best low cost method for the disinfection of drinking water in rural households. Disinfection efficiency was detected by comparing reduction in number of CFUs (Colony Forming Units) in the samples.

Boiling: Boiling or heating of water with fuel has been used to disinfect household water since ancient times. It is effective in destroying all classes of waterborne pathogens (viruses, bacteria and bacterial spores, fungi and protozoans and helminth ova) and can be effectively applied to all waters, including those high in turbidity or dissolved constituents. As per WHO Guidelines for Drinking Water Quality, 2002 water was kept in glass beakers for boiling at 80˚C and allowed for rolling boil for 1 to 5 minutes when it reached boiling. Samples of boiled water were collected at 5 minutes, 10 minutes, 20 minutes and 30 minutes (Plate 32). However, control samples were collected as soon as the boiling was started at 80˚C. These samples were plated on lauryl sulphate media to check disinfection. Plates were kept in BOD incubator at 37˚ C ± 1˚C up to 48 hours. Colonies were counted and recorded.

Chlorination: Of the drinking water disinfectants, free chlorine is the most widely used, the most easily used and the most affordable. It is also highly effective against nearly all waterborne pathogens. At doses of a few mg/l and contact times of about 30 minutes, free chlorine generally inactivates >4 log10 (>99.99%) of enteric bacteria and viruses. Government of India also promotes chlorination by providing free chlorine drops in rural households.

Experiments on chlorination were carried out on contaminated samples in all the seasons.

It was observed that Public Health and Engineering Department of Panvel, Raigad distributes Sodium Hypochlorite solution by trade name 'Jalshuddhi Nirjantuk 'among villagers. It is marked on the bottle of 100 ml. volume that it contains 4-5% sodium hypochlorite. It is advised to add 2 drops of solution in 10L of water for 10-15 minutes. It was observed that 1 drop of solution had a volume of 0.025 ml. So, in 10 L of drinking water 50 ppm of solution was required. On this basis experiments were designed with three dosages i.e. 1%, 2% and 4% of sodium hypochlorite solution for the time duration of up to 5 minutes, 10 minutes and 15 minutes to evaluate best dose of sodium hypochlorite and contact time.

Solar Disinfection (SODIS): It was conducted by keeping contaminated drinking water samples of 100 ml volume in glass bottles for the incubation time of 30 minutes,1 hour, 2 hour and 4 hour. Bottles were placed in a tray covered by black paper sheet (Plate-). The setup was exposed to direct sun from 11 am to 3 pm in all the seasons. Light intensity and temperature were recorded. At each incubation time samples were collected and plating was done on lauryl sulphate media for total coliforms.

7. Awareness Generation Programmes

Training cum awareness generation was imparted by audio- visual presentations and discussion. Posters were displayed and pamphlets were distributed among stakeholders in regional language. Questionnaires containing open ended and closed ended questions were prepared to check the knowledge and socio- economic profile of students before and after training programme. Pre and post knowledge questionnaires were same. Before filling up questionnaires, students were briefed about the aim of filling it and questions were discussed one by one to remove any confusion among them. Training programme was started after filling up questionnaires for pre knowledge test. Post knowledge questionnaires were filled up after the training. The questionnaires were arranged separately for pre and post survey. Coding of questionnaires was done to maintain uniformity of respondents. Coding of questions was done as per the standard practice for analysis. The data was analyzed by using MS Excel software. Correlation of independent variables (age, sex, education and family size) and dependent variables was done in order to check their affect on knowledge about drinking water purification before training. Two tailed T- test was performed on pre and post questionnaires to study the improvement of knowledge level of respondents after training programme.

8. Statistical analysis

The data collected before and after training programmes were analyzed for the assessment of impact of training. Correlation of dependent variables with independent variables was conducted to ascertain significant relationship between different variables and knowledge level of respondents about different aspects of drinking water. Two tailed T test was performed to know the effect of training on respondents after awareness generation programmes. All the analysis was performed by using MS Excel 2007.

RESULTS: MAJOR FINDINGS OF THE PROJECT

1. Survey of Water Availability, Assessment of Problems Related to Drinking Water Quality in Selected Villages in Panvel, Navi Mumbai

In order to understand the source, availability quality and other related problems connected with drinking water in the chosen villages, namely, Chinchovli, Vangni, Shanthivan, Waze, Bhanghar and Usurli beyond Panvel a field survey was conducted. A set of questionnaire was made and feedback was collected from the local population. Total 150 respondents comprising school children and villagers were involved. The composition of the respondents is given below.

Table 6: Composition of respondents

Sr. No.	Group	Total no. of respondents	No. of Males	No. of Females	Age Group	Occupation
1	I	112	55	57	13 -15	Students
2	II	38	36	2	24-67	Farming and service

The questionnaire covered three main aspects, namely availability and quality of drinking water, sewage waste disposal methods available and the prevalence of water borne diseases. The questionnaire also covered their existing knowledge level on the purification of water (Annexure- I).

Main source of drinking water was bore well in selected areas (Figure 1). 122 of the respondents reported to use bore well water as their drinking water source and 28 use open well water. Out of 150 respondents 75 have bore well at home and the rest do not have bore wells (Figure 2). Same water is used in all seasons and drying of bore well source is not reported. 126 said that suspended impurities are absent in drinking water and 24 said that suspended impurities are present (Figure 3). 141 respondents have said that the water is sweet. 7 admit that the water is slightly salty (Figure 4). 94 respondents out of 150 use commercially obtained filters (Figure 5 & 6). 60 respondents reported that a filter cloth is used for filtering water. 12 respondents said that simple decantation is practiced (Figure 5).

75 respondents use water purification units at home and 63 respondents do not use any water purification units at home and rest have not given any response (Figure 6). These units are in use for varying periods of up to 5 years (Figure 7).

51 respondents said that these water purification units are periodically serviced. 67 respondents said that these are not periodically serviced. Others have not given any response (Figure 7). 78 respondents boil water before drinking and 71 do not boil water before drinking (Figure 8).

93 respondents said that no salt deposits seen in the vessel after boiling while 36 said that salt deposition is seen (Figure 9). 74 respondents said that they drink water available in the area outside home. 59 respondents carry water from home when they go outside. 15 respondents said that they buy mineral water bottles (Figure 10).

For knowledge on water purification methods 55 respondents said that they are aware of water purification process while 90 respondents admit that they don't know any water purification process (Figure 11). Out of 150 total respondents 5 have not reported any information.

About the information on water borne diseases 119 respondents could name a few diseases caused by water contamination while 31 respondents couldn't name any (Figure 12).

Out of 150 respondents 112 said that toilet is available at home while 38 respondents said that they don't have toilet at home (Figure 13).

Out of 119 respondents 109 said that the toilet discharge is directly connected to a septic tank. 8 respondents said that it directly flows to an open nullah. 2 respondents said that it is connected to the main sewage lines. However, 31 respondents have not mentioned any information (Figure 14).

Distance of septic tank from drinking water sources is crucial. Out of 150 respondents 128 said that the bore well is beyond 30 feet from septic tank. 16 said that the bore well is between 20 to 30 feet distance from septic tank. 4 said that the bore well is at a distance of 10 to 20 feet while 2 said that the distance could be less than 10 feet (Figure 15).

Regarding water source available for other than drinking purpose out of 150 respondents 117 said that they have an open well nearby while 33 said that they have an open tank nearby (Figure 16).

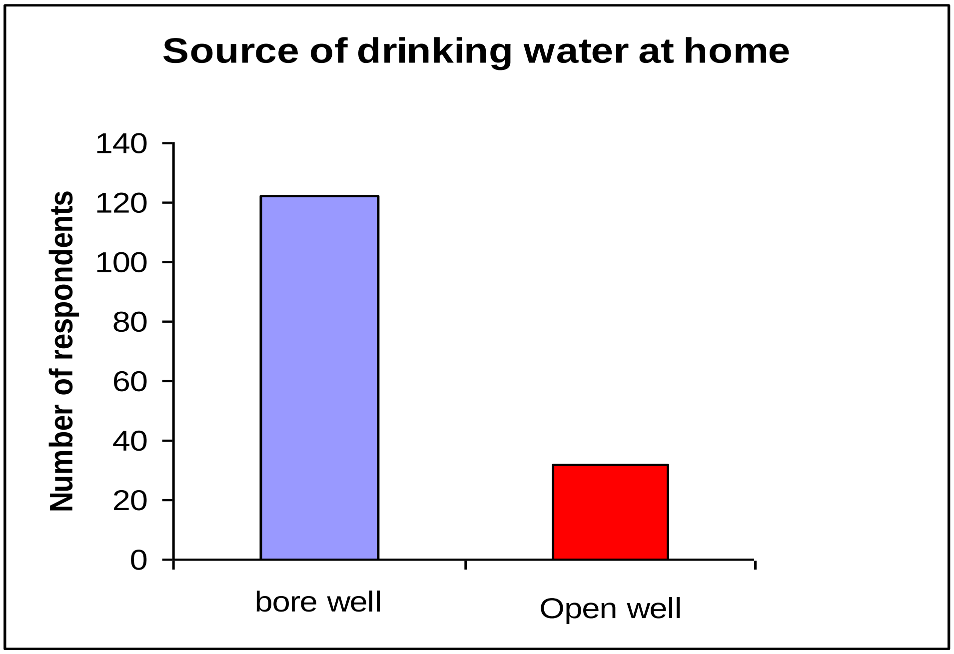


Figure 1: Sources of drinking water in selected areas

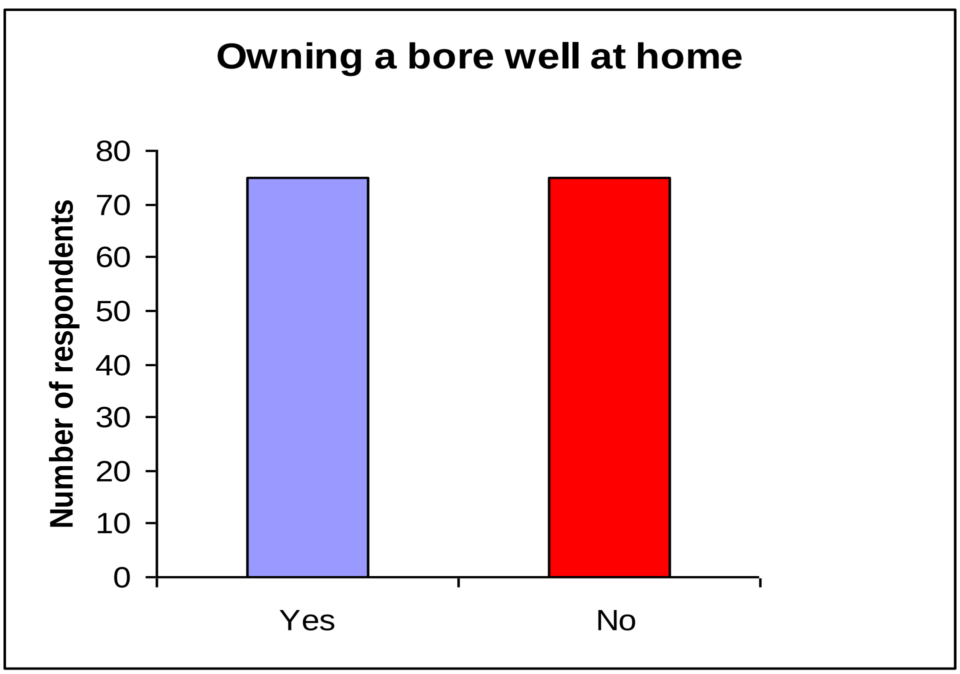


Figure 2: No. of respondents having a bore well at home

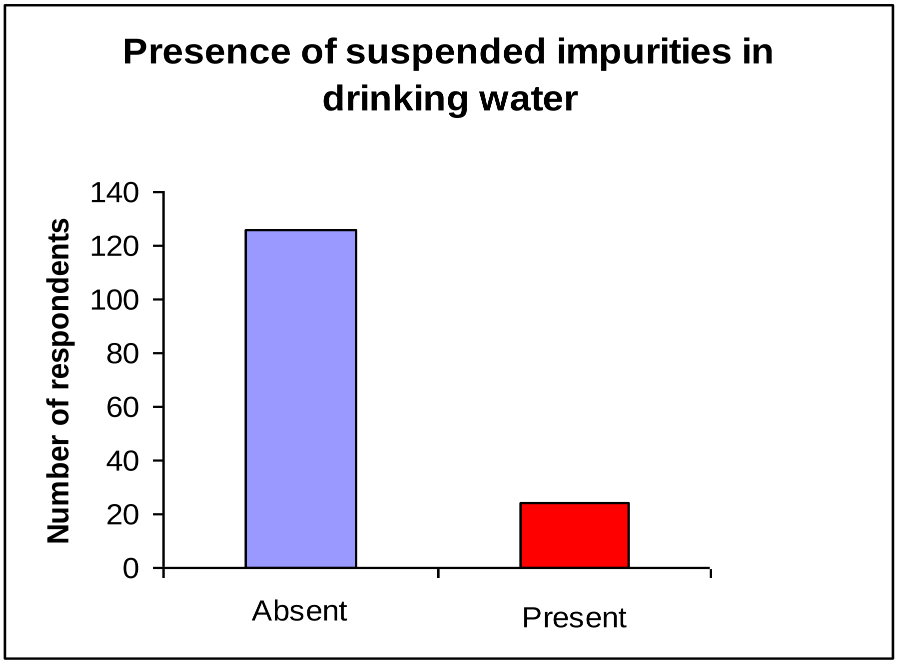


Figure 3: Presence of suspended impurities in drinking water

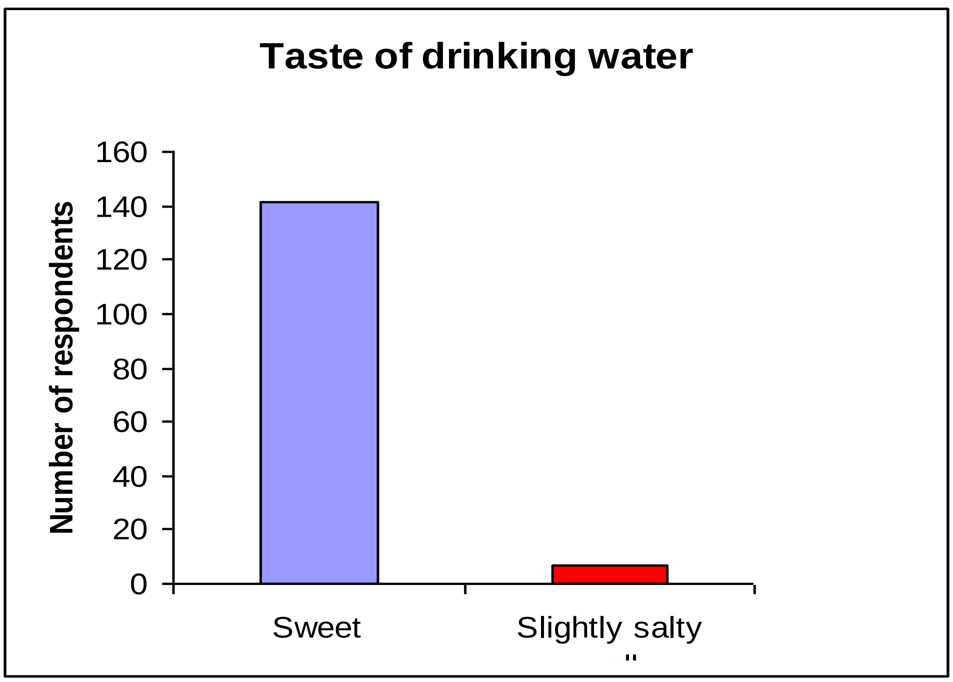


Figure 4: Response regarding taste of drinking water

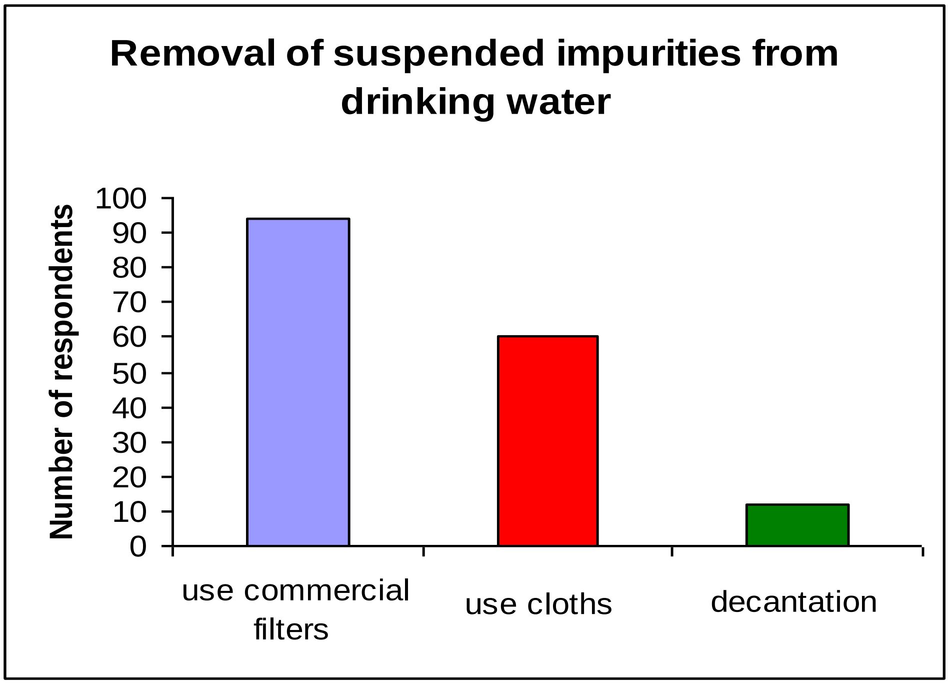


Figure 5: Methods for the removal of suspended impurities from drinking water

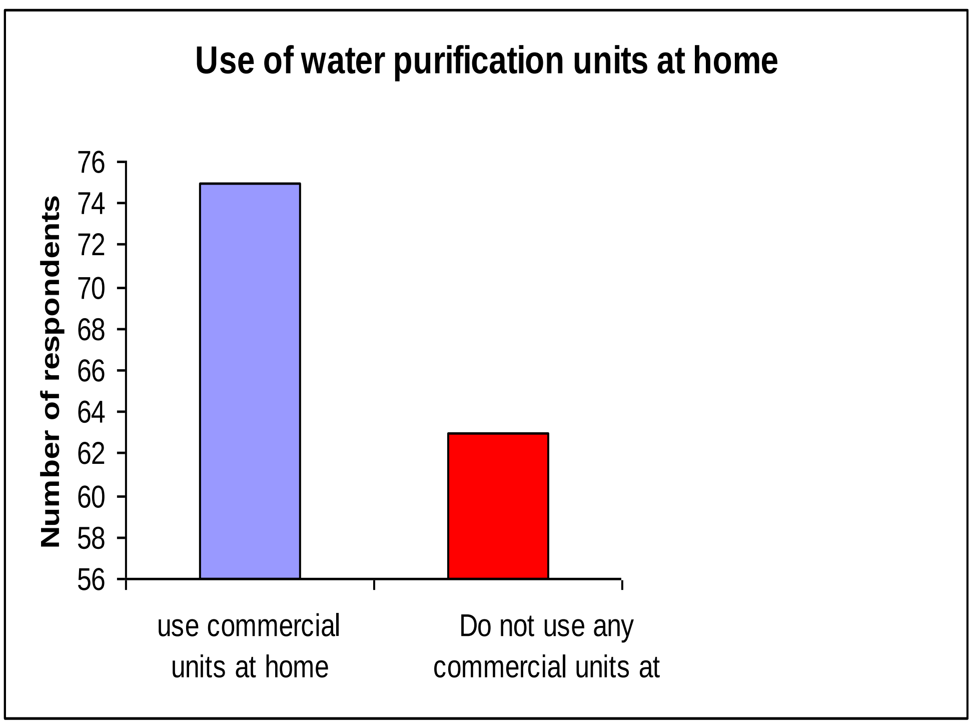


Figure 6: Use of water purification at home

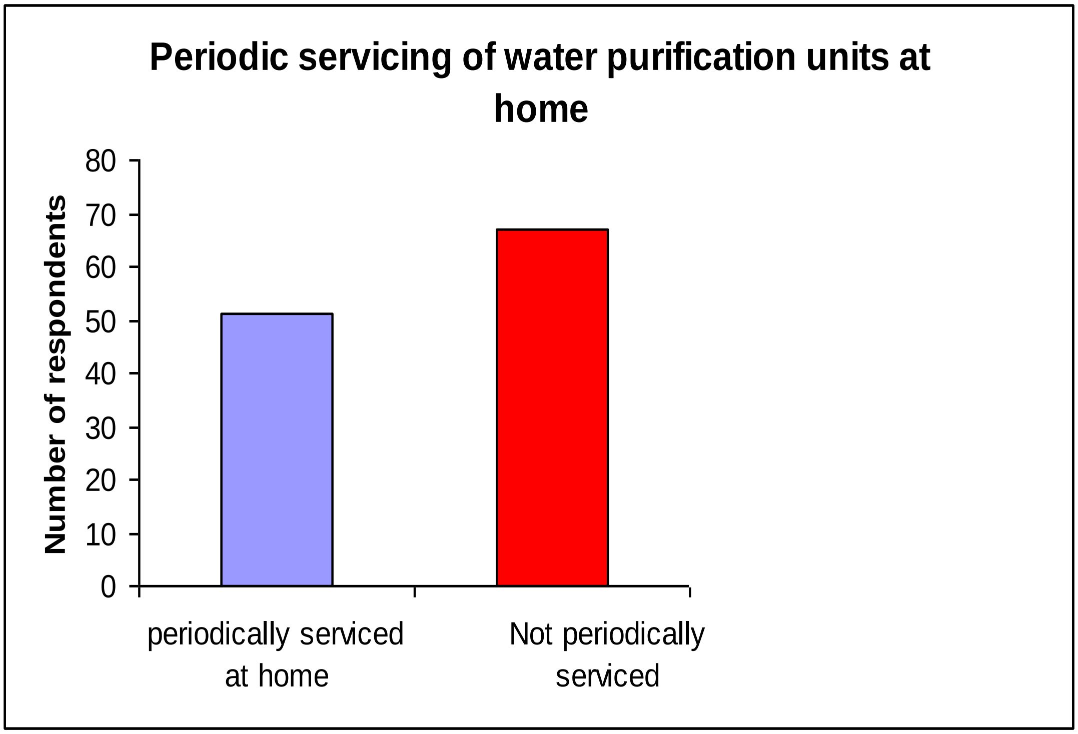


Figure 7: Periodic servicing of water purification units at home

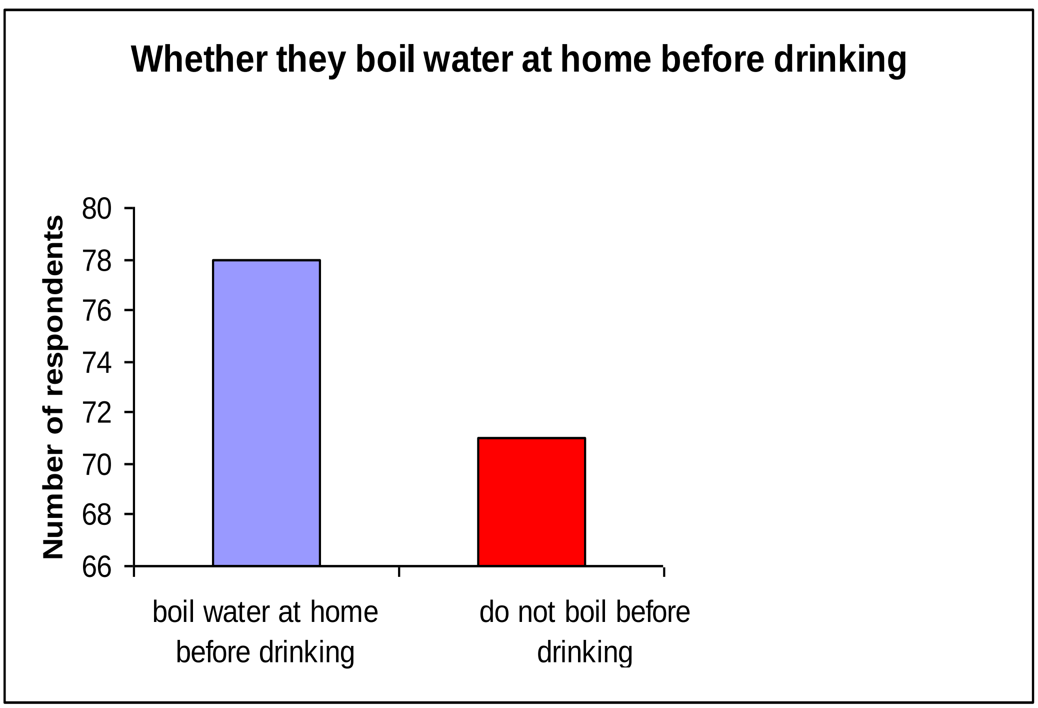


Figure 8: Boiling of drinking water before use

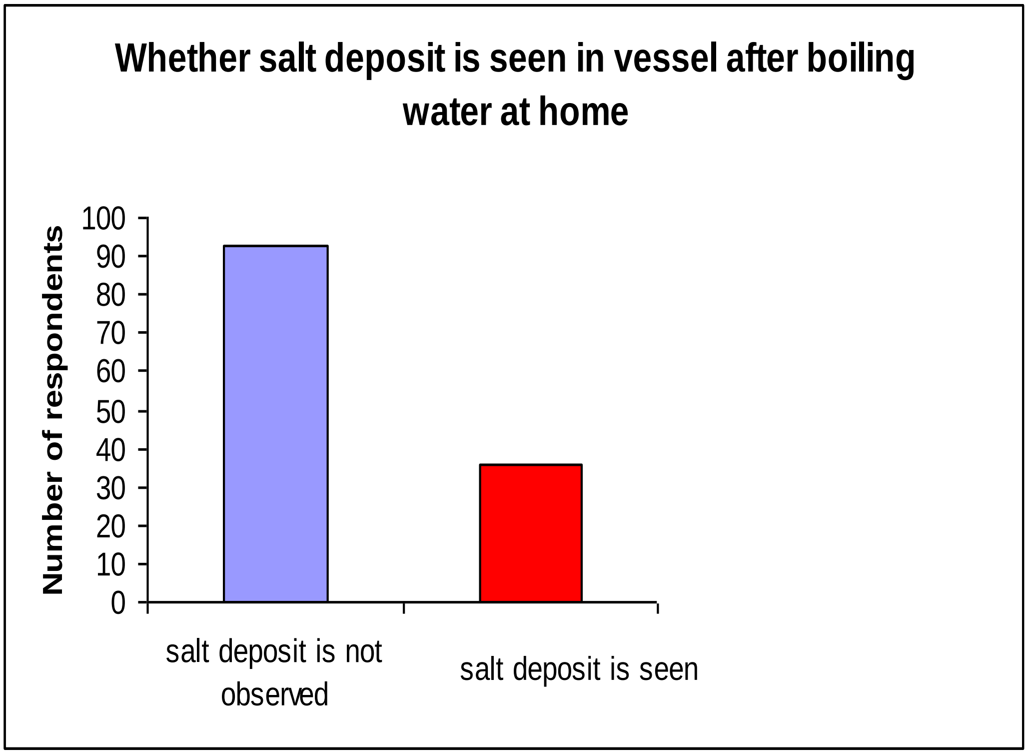


Figure 9: Information about salt deposition in containers

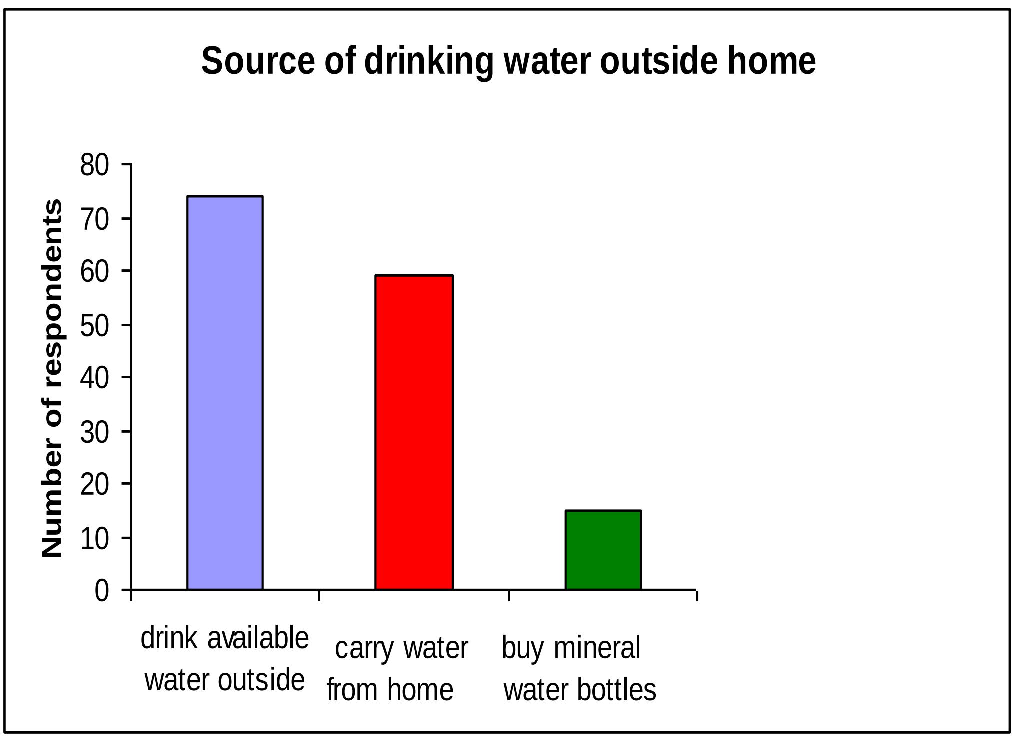


Figure 10: Information about source of drinking water outside home

For proper water management drinking water should be away from the water used for other purpose. Out of 150 respondents 87 said that they use different sources of water for drinking, cooking and washing while 63 said that they use the same water (Figure 17). It was observed that storage of water of drinking and other requirements was not separate. Due to which cleanliness of storage containers was observed as a major issue in water quality.

Regarding the source of water for washing out of 150 respondents, 43 said that they use the same bore well water. 8 respondents said that they use open well water and 19 said that open tank water is used. 34 said that river water is used for washing purpose and 46 said that water from a nearby lake is used (Figure 18). It was observed that villagers commonly wash cloths from river water as well as pond water.

Regarding the foaming ability of water used for washing out of 146 respondents 126 said that it is good while 20 said that it is poor (Figure 19). This could be correlated with the absence of salt deposition on the bottom of containers after water storage (Figure 9). Regarding any occurrence of vomiting and diarrhea, out of 150 respondents 114 said that nothing like that happened in the past. 36 said that they suffered (Figure 20).

Information on water borne diseases is very important to assess the quality of water. Regarding the particular season for disease occurrence, respondents were not very clear; however on focused discussion some have said that during monsoon frequency of water borne diseases is more. Regarding the frequency of occurrence of water borne diseases, out of 150 respondents 56 said that it is more than three times a year while 48 said that it is thrice a year and 46 said that it is twice a year (Figure 21). Other family members were also reported to fall sick due to contaminated drinking water (Figure 22).

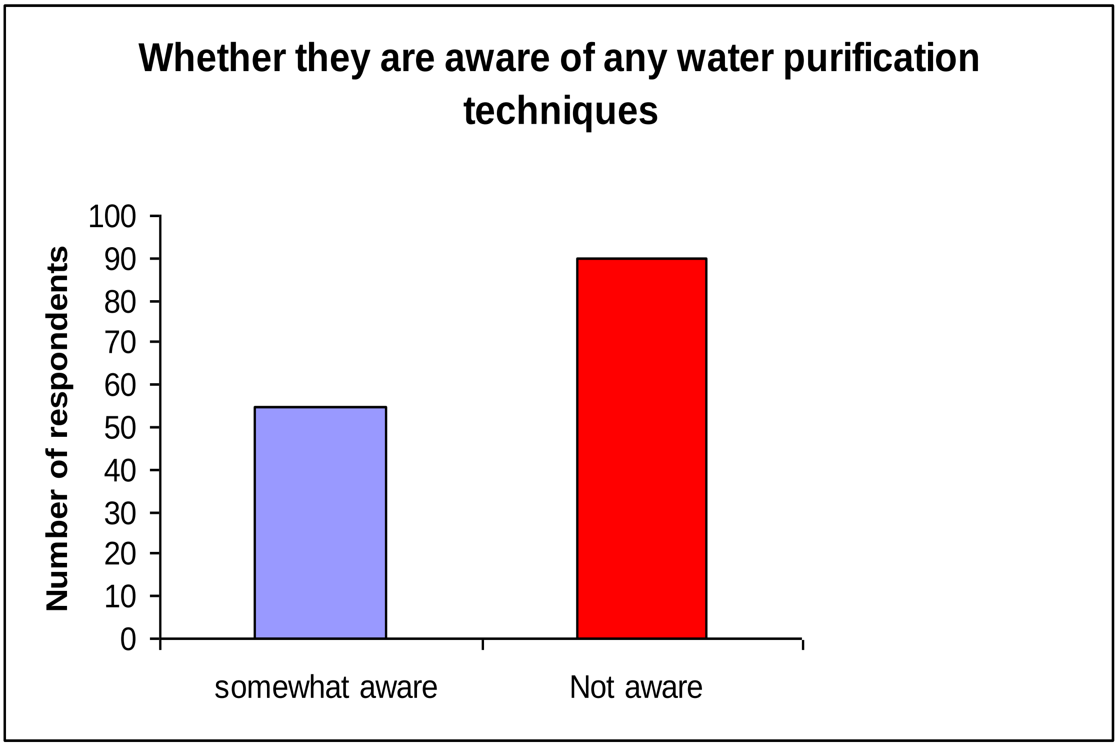


Figure 11: Awareness about water purification techniques

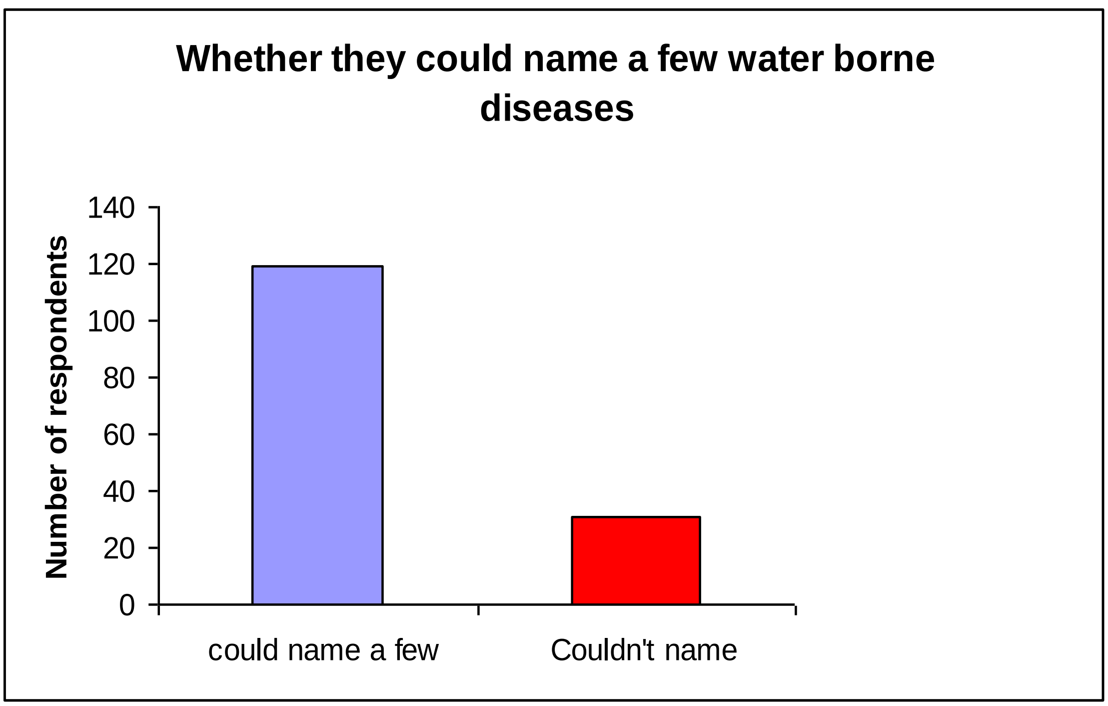


Figure 12: Information about water borne diseases

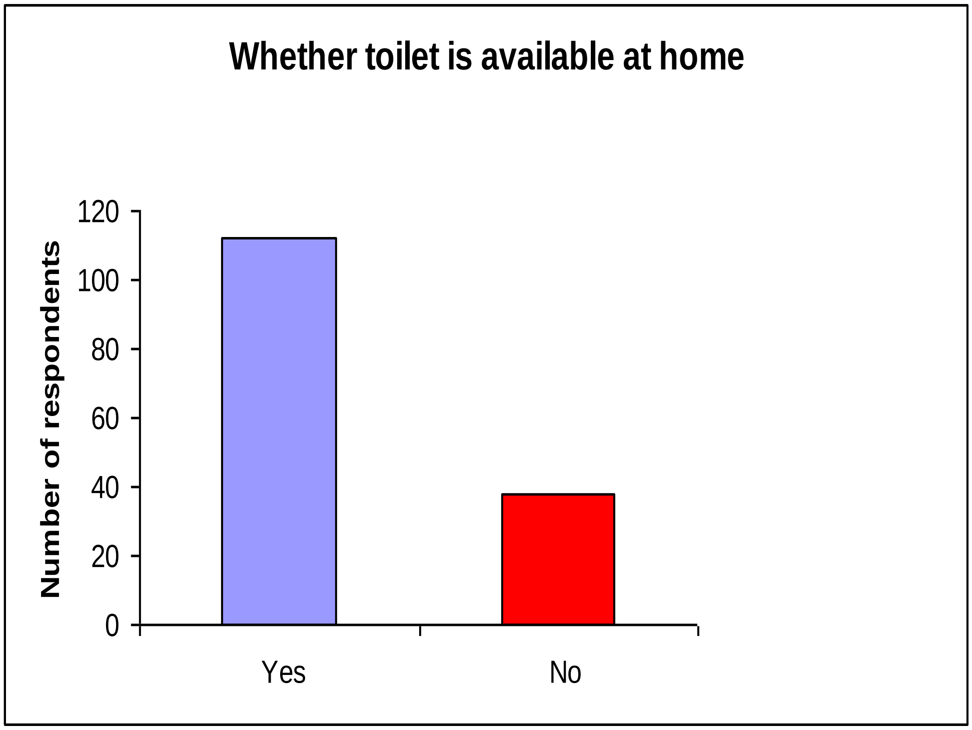


Figure 13: Information on the availability of toilet at home.

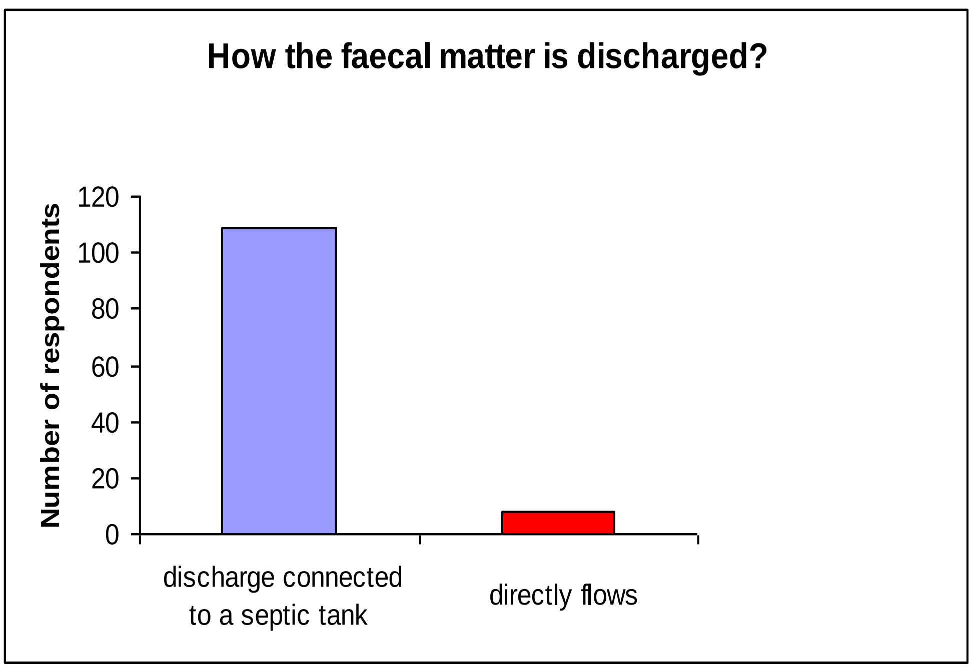


Figure 14: Information about discharge of faecal matter

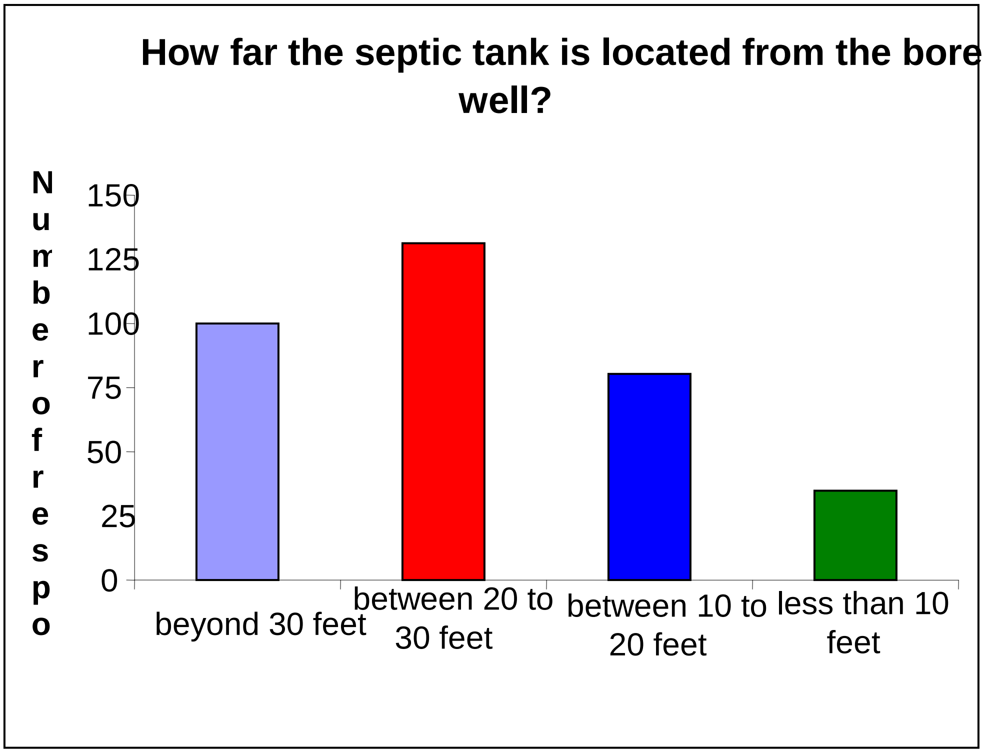


Figure 15: Information on distance of septic tank from the bore well?

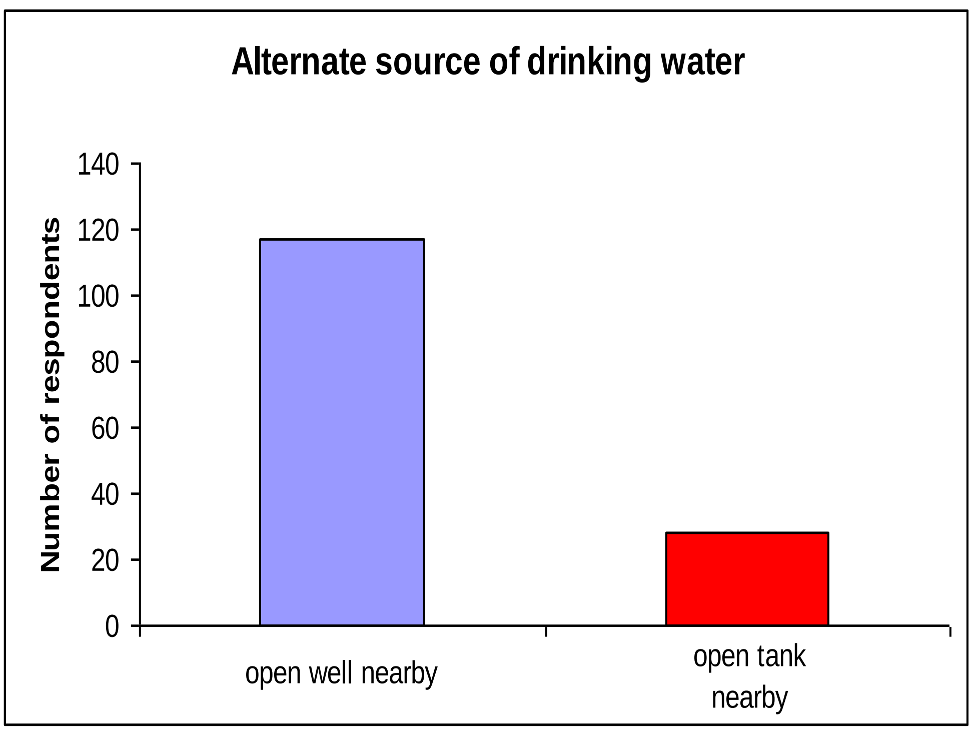


Figure 16: Information on alternative source of drinking water

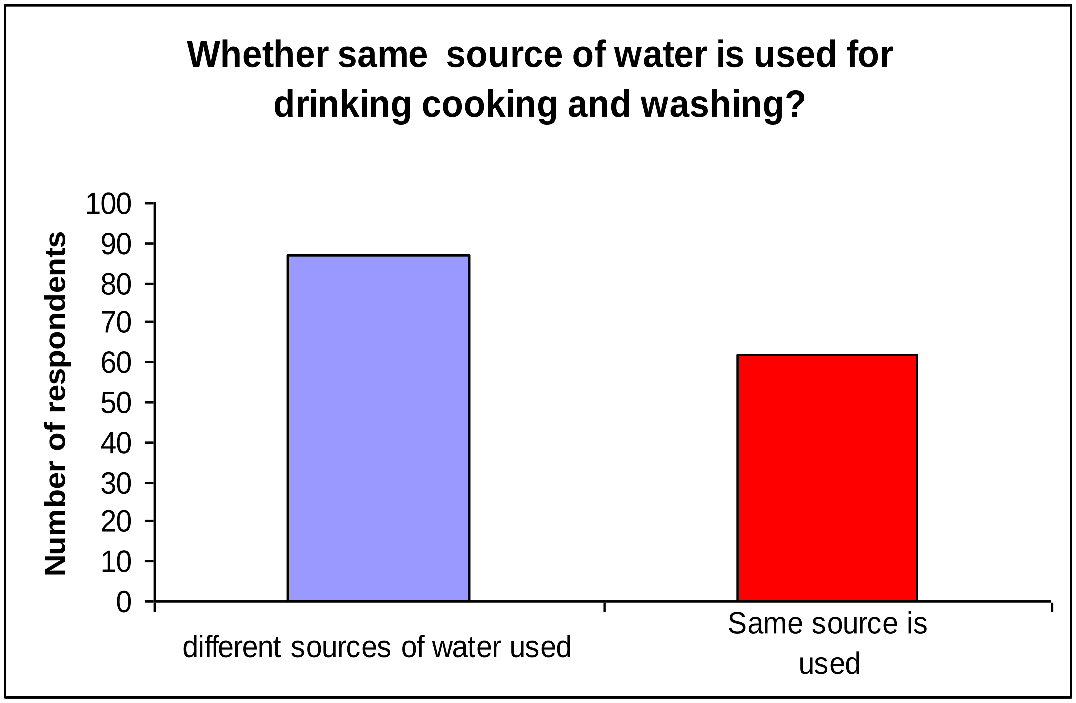


Figure 17: Information on the source of water used for drinking cooking and washing

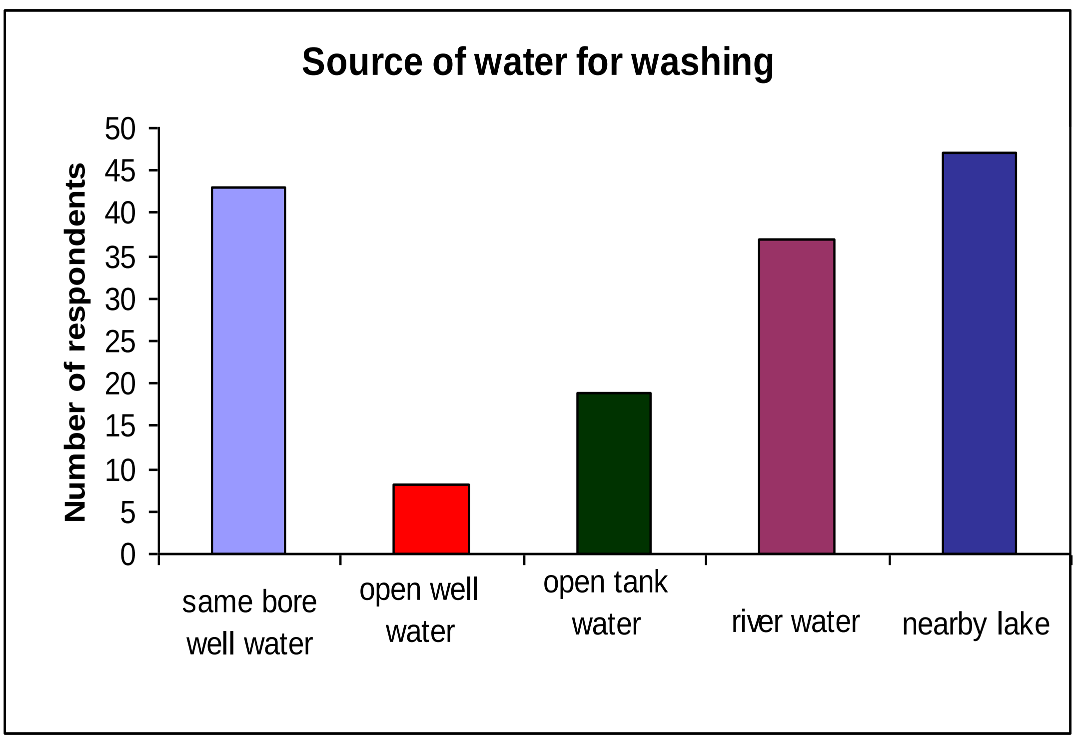


Figure 18: Source of water for washing

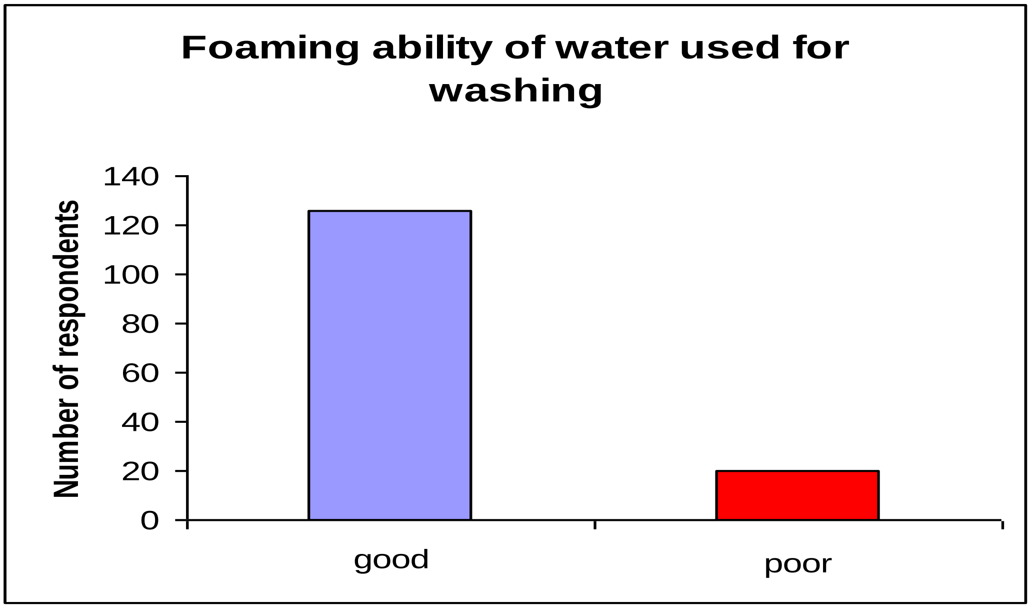


Figure 19: Foaming ability of water used for washing

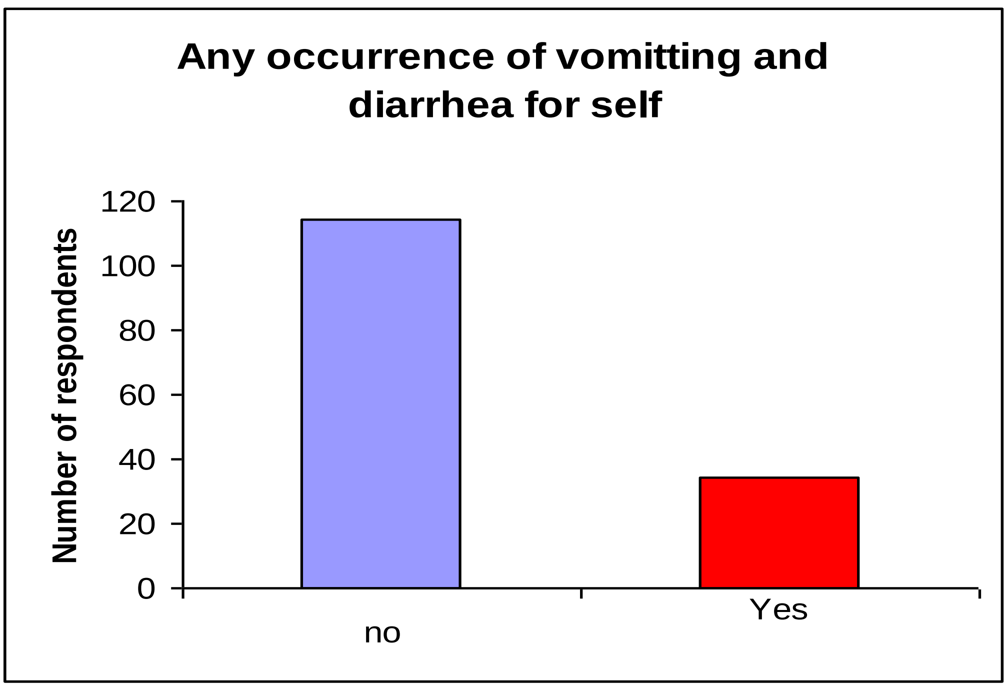


Figure 20: Information on the occurrence of vomiting and diarrhea

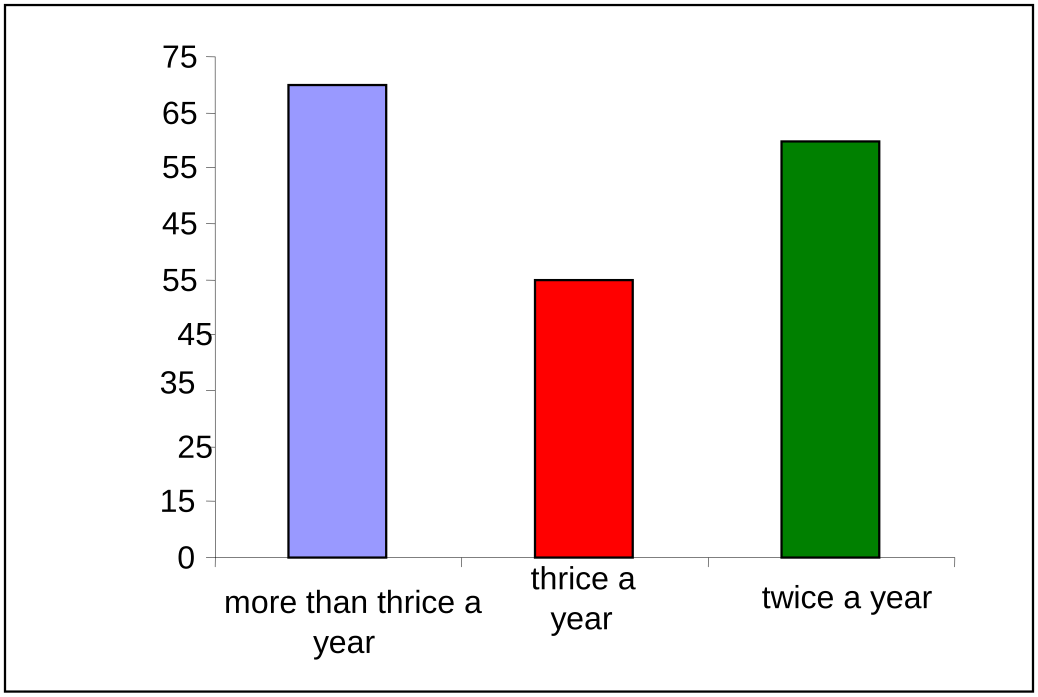


Figure 21: Frequency of occurrence of water borne diseases

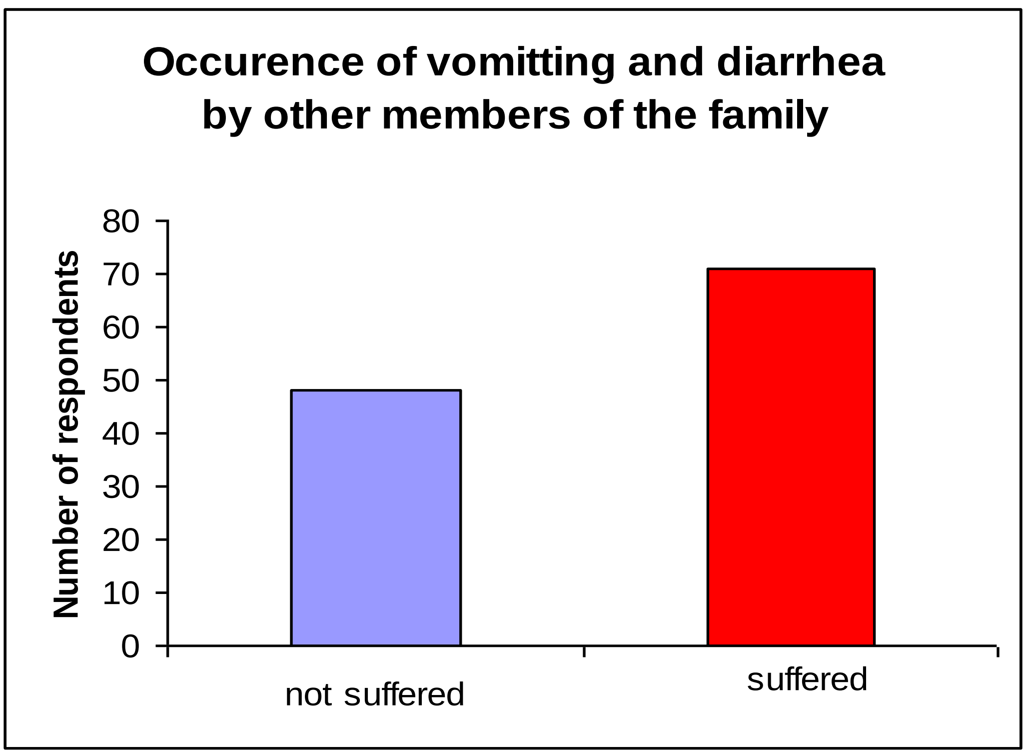


Figure 22: Occurrence of vomiting and diarrhea by other members of the family

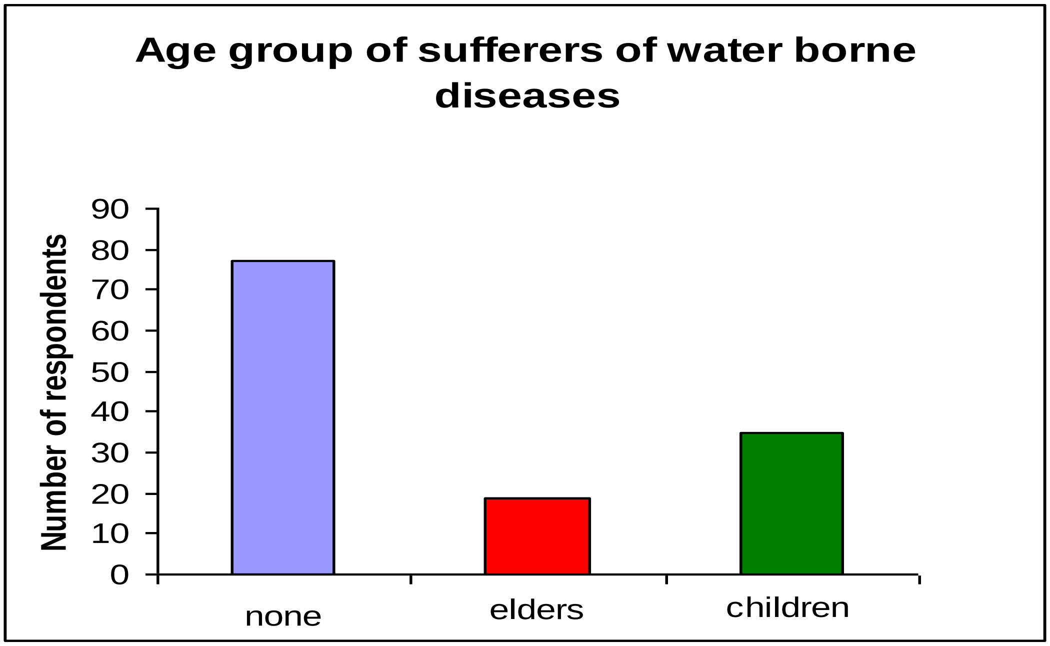


Figure 23: Information on age group of sufferers of water borne diseases

Regarding age group of sufferers out of 134 respondents 77 said that none and 19 said that elders suffered and 33 said that children suffered (Figure 23). Remaining 16 respondents have not given any reply. Regarding presence of bacteria or microbial toxins in drinking water 18 said that it is present while 51 said that it is not present while 76 said that they have no idea, however, 5 have not replied anything (Figure 24). Regarding diseases often encountered out of 124 respondents 17 said that they suffered from cholera, 6 said that they suffered from typhoid, 68 said that they suffered from jaundice. 25 respondents said that they suffered from malaria and 8 suffered from skin diseases, 26 respondents have not given any answer (Figure 25).

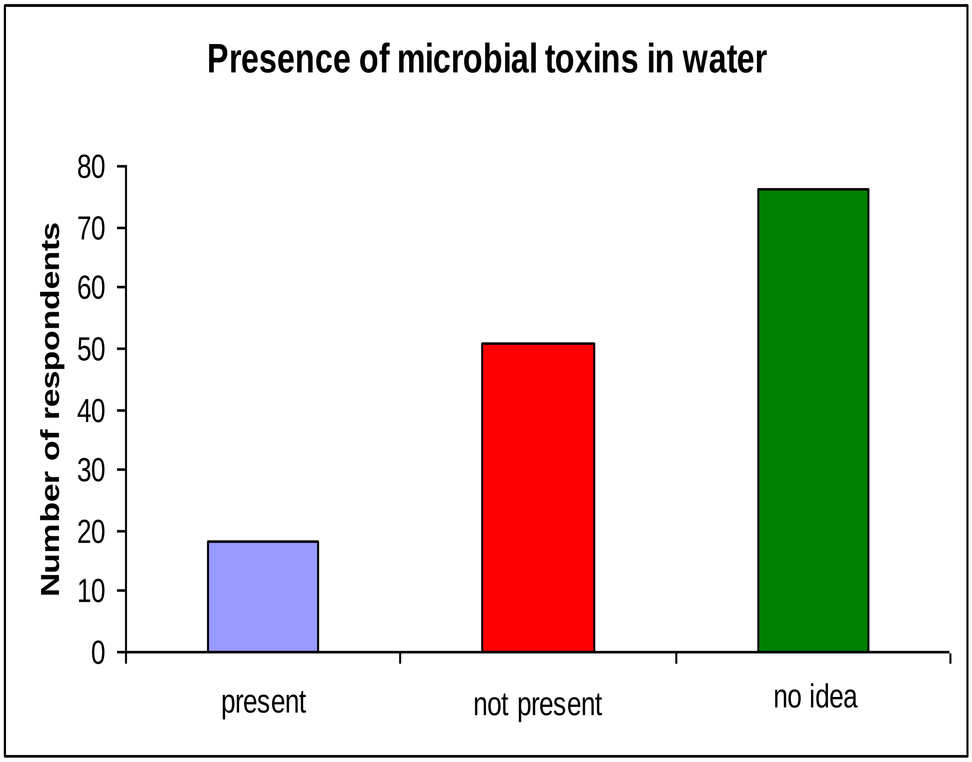


Figure 24: Presence of microbial toxins in water

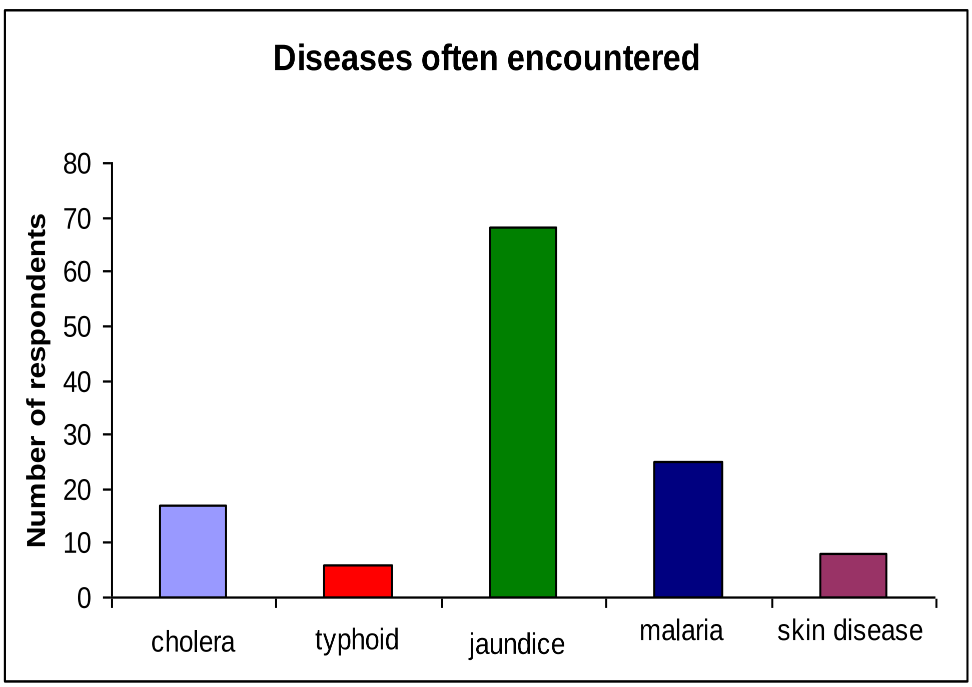


Figure 25: Diseases often encountered

2. Physical, Chemical and Microbial Quality of Drinking Water Samples Collected from Selected Sites in Panvel during Different Seasons

The drinking water samples were collected in post monsoon season in February 2014, pre- monsoon season in May 2014 and in monsoon season in August 2014 (Table 2) from selected sites near Panvel (M. S.). Total 54 samples including 22 in post monsoon season, 16 in pre monsoon and 16 in monsoon season was collected. The samples were collected as per the standard methods in triplicates and transported same day to lab and stored as per the requirement. The results for different parameters is presented as below-

Physical Parameters

i. Temperature

Temperature ranged from 25˚ C to 32˚ C in different seasons (Table 6). Highest temperature was recorded in post monsoon season as well as monsoon season in bore well samples. Lowest temperature was recorded in monsoon season. Water temperatures fluctuate naturally both daily and seasonally. Temperature also affects solubility of oxygen in water. Solubility of oxygen in water increases with decreasing temperature.

Table 7: Drinking water temperature (˚C) during different seasons from selected sites

Location with sources of water	Post Monsoon	Pre monsoon	Monsoon
WHO Standard- 30˚C ; IS:10500 Standard- Not present			
Ashramshala, Shantivan (handpump)	28	29	27
Ashramshala, Shantivan (well water)	30	29	27
New English School (bore well)	32	--	--
Waje School (borewell)	32	28	28
Usurli (handpump)	31	29	25
Usurli(borewell)	29	28	25
Usurli(borewell)	30	28	26
Usurli (borewell	30	27	28
Chinchovli(borewell)	28	29	27
Chinchovli(borewell)	27	27	26
Chinchovli(borewell)	29	27	25
Vangani (borewell)	30	29	26
Vangani (borewell)	32	28	32
Vangani (borewell)	30	28	30
Nere high school (borewell)	28	27	27
Usurli (abandoned well)	--	29	29
Shantivan (river)	--	28	28

ii. pH

The pH of drinking water samples was in the range of 7.26 to 7.94 (Table 7). The lowest pH was in Waje School bore well water during pre monsoon season; however, in same sample during post monsoon and monsoon season pH was 7.37 and 7.35, respectively. The maximum permissible limit of pH as prescribed by Indian Standard for Drinking water is 6.5 to 8.50. All the samples have pH values within the desirable and suitable range.

Table 8: pH of drinking water samples from selected sites during different seasons

Location and sources of water	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 6.5-8.5; IS:10500 Standard: 6.5-8.5			
Ashramshala (handpump)	7.37	7.41	7.76
Ashramshala (well water)	7.54	7.67	7.35
New English School (borewell)	7.74	--	--
Waje School, Waje (borewell)	7.64	7.26	7.66
Usurli (handpump)	7.83	7.76	7.55
Usurli (borewell)	7.73	7.48	7.42
Usurli (borewell)	7.90	7.41	7.63
Usurli (borewell	7.65	7.67	7.54
Chinchovli (borewell)	7.31	7.24	7.72
Chinchovli (borewell)	7.44	7.29	7.73
Chinchovli (borewell)	7.25	7.94	7.97
Vangani (borewell)	7.71	7.84	7.42
Vangani (borewell)	7.34	7.71	7.62
Vangani (borewell)	7.62	7.73	7.63
Nere High School (borewell)	7.41	7.17	7.41
Usurli (abandoned well)	--	7.67	7.38
Shantivan (river)	--	7.94	7.30

iii. Electrical conductivity

Electrical conductivity is considered to be a rapid and good measure of dissolved solids. It was in the range of 0.25 to 0.89 mS/cm in different seasons and was within permissible limit. A clear trend in the increase or decrease in EC with season was not observed (Table 9). The maximum value of EC was in the bore well of Nere High School, Nere during pre- monsoon season.

Table 9: Electrical conductivity (mS cm^{-1}) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 1.8 ; IS:10500 Standard: Not Present			
Ashramshala (handpump)	0.398	0.36	0.43
Ashramshala (well water)	0.40	0.38	0.25
New English School (borewell)	0.48	--	--
Waje School, Waje (borewell)	0.31	0.30	0.26
Usurli (handpump)	0.545	0.46	0.53
Usurli (borewell)	0.589	0.52	0.40
Usurli (borewell)	0.59	0.49	0.70
Usurli (borewell	0.60	0.58	0.81
Chinchovli (borewell)	0.53	0.43	0.83
Chinchovli (borewell)	0.56	0.55	0.55
Chinchovli (borewell)	0.43	0.57	0.53
Vangani (borewell)	0.68	0.55	0.56
Vangani (borewell)	0.63	0.67	0.78
Vangani (borewell)	0.72	0.67	0.78
Nere High School (borewell)	0.65	0.89	0.85
Usurli (abandoned well)	--	0.55	0.57
Shantivan (river)	--	0.27	0.30

iv. Total Dissolved Solids (TDS)

TDS was more during monsoon season in majority of samples (Table 10). In Vangani village drinking water samples had comparatively more TDS in comparison to permissible limit. River water samples had more TDS during monsoon season in comparison to pre monsoon. It could be due to high amount of soil and sediment in rivers during monsoon.

Table 10: Total Dissolved Solids data (mg/L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 500 ; IS:10500 Standard: 500			
Ashramshala (handpump)	258	220	303
Ashramshala (well water)	267	170	174
New English School (borewell)	317	--	--
Waje School, Waje (borewell)	207	150	150
Usurli (handpump)	355	120	450
Usurli (borewell)	384	260	580
Usurli (borewell)	391	340	500
Usurli (borewell	399	310	450
Chinchovli (borewell)	348	240	400
Chinchovli (borewell)	369	400	400
Chinchovli (borewell)	287	350	350
Vangani (borewell)	453	320	600
Vangani (borewell)	415	550	500
Vangani (borewell)	474	550	600
Nere High School (borewell)	428	590	220
Usurli (abandoned well)	--	590	450
Shantivan (river)	--	220	650

v. Turbidity

The samples from Vangani village had more turbidity in comparison to other sites (Table 11) and permissible limits as per WHO. However, as per Indian Standard for Drinking Water river and abandoned well samples had higher values specifically in pre monsoon and postmonsoon seasons. Majority of bore well samples had high turbidity during rainy season.

Table 11: Turbidity (NTU) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 5 ; IS:10500 Standard: 10			
Ashramshala (handpump)	2.9	1.8	1.2
Ashramshala (well water)	1.1	2.5	4.3
New English School (borewell)	3.7	--	--
Waje School, Waje (borewell)	0.04	0.8	0.97
Usurli (handpump)	0.6	0.4	6.9
Usurli (borewell)	4.0	4.3	4.4
Usurli (borewell)	2.8	5.2	1.1
Usurli (borewell	1.0	3.9	4.4
Chinchovli (borewell)	2.5	1.3	8.5
Chinchovli (borewell)	3.4	2.0	3.5
Chinchovli (borewell)	0.9	5.1	2.9
Vangani (borewell)	2.6	4.7	5.2
Vangani (borewell)	2.7	5.5	6.17
Vangani (borewell)	1.9	4.2	6.9
Nere High School (borewell)	1.4	4.9	8.0
Usurli (abandoned well)	--	20.9	14
Shantivan (river)	--	37.5	11.4

Chemical Parameters

i. Total alkalinity

Total alkalinity was above permissible limits in some bore well water samples during monsoon (Table 12). Samples collected from Vangani, Usurli and Nere had comparatively more alkalinity than other samples. River water sample alkalinity was within permissible limit.

Table 12: Total Alkalinity (mg $CaCO_3$ / L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 250 ; IS:10500 Standard: 250			
Ashramshala (handpump)	210	241.5	310
Ashramshala (well water)	183.8	241.5	172
New English School (borewell)	262.5	--	--
Waje School, Waje (borewell)	78.8	69	172
Usurli (handpump)	78.8	69	276
Usurli (borewell)	105	69	207
Usurli (borewell)	105	69	241
Usurli (borewell	105	69	310
Chinchovli (borewell)	105	138	276
Chinchovli (borewell)	131.3	138	310
Chinchovli (borewell)	131.3	103.5	287
Vangani (borewell)	78.8	69	183
Vangani (borewell)	262.5	69	207
Vangani (borewell)	131.3	138	276
Nere High School (borewell)	236.3	241.5	552
Usurli (abandoned well)	--	345	276
Shantivan (river)	--	103..5	69

ii. Free CO_2

High amount of CO_2 in water is not desirable since it promotes microbes in water samples (Table 13). In all the samples free CO_2 was very low in comparison to permissible limit of WHO. In rainy season free CO_2 was more in all the samples. River water samples in pre monsoon as well as post monsoon season had more $CO_{2.}$

Table 13: Free Carbon Dioxide (mg/L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 2 ; IS:10500 Standard: Not Present			
Ashramshala (handpump)	0.0137	0.013	0.089
Ashramshala (well water)	0.0173	0.023	0.035
New English School (borewell)	0.0274	--	--
Waje School, Waje (borewell)	0.0218	0.009	0.044
Usurli (handpump)	0.034	0.028	0.056
Usurli (borewell)	0.026	0.015	0.076
Usurli (borewell)	0.040	0.012	0.047
Usurli (borewell	0.0203	0.023	0.058
Chinchovli(borewell)	0.0102	0.008	0.034
Chinchovli(borewell)	0.0137	0.006	0.034
Chinchovli(borewell)	0.0088	0.043	0.039
Vangani (borewell)	0.0256	0.034	0.076
Vangani (borewell)	0.0109	0.025	0.032
Vangani (borewell)	0.0208	0.026	0.032
Nere High School (borewell)	0.0128	0.007	0.028
Usurli (abandoned well)	--	0.023	0.012
Shantivan (river)	--	0.043	0.009

iii. Dissolve Oxygen

Dissolve oxygen was within permissible limit in all the samples (Table 14). A clear trend due to seasons or sources was not observed in any sample. It ranged from 0.33 to 1.9 mg/L.

Table 14: Dissolved Oxygen data (mg /L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 5 ; IS:10500 Standard: 6			
Ashramshala (handpump)	1.39	1.653	1.48
Ashramshala (well water)	1.19	1.521	1.48
New English School (borewell)	1.49	--	--
Waje School, Waje (borewell)	1.49	0.86	1.58
Usurli (handpump)	1.79	1.03	0.79
Usurli (borewell)	1.69	1.03	1.78
Usurli (borewell)	1.49	1.26	1.78
Usurli (borewell	1.79	1.12	1.25
Chinchovli (borewell)	1.49	1.16	1.68
Chinchovli (borewell)	1.19	1.55	0.79
Chinchovli (borewell)	1.29	1.52	1.68
Vangani (borewell)	1.34	1.52	1.90
Vangani (borewell)	0.99	1.42	1.90
Vangani (borewell)	1.59	1.42	1.90
Nere High School (borewell)	0.79	1.12	1.21
Usurli (abandoned well)	--	0.826	1.58
Shantivan (river)	--	0.330	1.78

iv. Total Hardness

The hardness of water is not pollution parameter but indicates water quality mainly in terms of Ca2+ and Mg2+ expressed as $CaCO_3$. Bore well water of Usurli, Chinchovli and Vangani villages had high hardness during pre monsoon and monsoon seasons in comparison to post monsoon season and other sites (Table 15).

Table 15: Total Hardness (mg/ $CaCO_3$ L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 500 ; IS:10500 Standard: 300			
Ashramshala (handpump)	221.76	376.32	303
Ashramshala (well water)	211.2	376.32	174
New English School (borewell)	137.28	--	--
Waje School, Waje (borewell)	47.52	117.6	184
Usurli (handpump)	116.16	203.84	381
Usurli (borewell)	132	196	255
Usurli (borewell)	264	250.88	532
Usurli (borewell	137.28	235.2	648
Chinchovli (borewell)	253.14	203.84	641
Chinchovli (borewell)	163.68	313.6	410
Chinchovli (borewell)	216.48	235.2	444
Vangani (borewell)	264	320.00	445
Vangani (borewell)	269.28	368.48	427
Vangani borewell)	200.64	282.24	426
Nere High School (borewell)	227.04	243.04	103
Usurli (abandoned well)	--	509.6	115
Shantivan (river)	--	203.84	120

v. Chloride

Chloride content was within permissible limit in all the seasons as well as sites (Table 16). A clear trend of increase or decrease in chloride content was not observed due to seasonal changes.

Table 16: Chloride content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 250 ; IS:10500 Standard: 250			
Ashramshala (handpump)	15.0	14.25	28.36
Ashramshala (well water)	40.0	14.25	28.36
New English School (borewell)	55.0	--	--
Waje School, Waje (borewell)	53.0	47.41	36.36
Usurli (handpump)	95.0	97.40	68.00
Usurli(borewell)	93.0	102.15	39.70
Usurli (borewell)	93.0	102.15	99.26
Usurli (borewell	125	104.53	110.60
Chinchovli (borewell)	38.0	90.27	161.60
Chinchovli (borewell)	125	97.40	68.00
Chinchovli (borewell)	13.0	123.53	99.26
Vangani (borewell)	95.0	121.16	99.26
Vangani (borewell)	63.0	147.29	68.00
Vangani (borewell)	123.0	190.05	150.00
Nere High School (borewell)	123.1	123.53	78.00
Usurli (abandoned well)	--	116.40	56.71
Shantivan (river)	--	30.88	11.37

vi. Sulphate

Sulphate content was under permissible limit in all the samples and seasons (Table 17). Excess sodium sulphate should not be present in drinking water as they cause cathartic action as well as respiratory diseases.

Table 17: Sulphate content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 150- 400 ; IS:10500 Standard: 250			
Ashramshala (handpump)	38.38	30.476	25.68
Ashramshala (well water)	13.53	21.777	17.43
New English School (borewell)	34.285	--	--
Waje School, Waje (borewell)	35.95	38.16	20.18
Usurli (handpump)	28.68	105.485	43.34
Usurli (borewell)	34.56	129.229	26.37
Usurli (borewell)	53.37	128.436	41.00
Usurli (borewell	29.89	38.666	47.90
Chinchovli (borewell)	20.60	43.518	70.87
Chinchovli (borewell)	34.42	43.530	32.56
Chinchovli (borewell)	5.25	119.114	39.44
Vangani (borewell)	27.87	62.530	36.23
Vangani (borewell)	50.95	42.283	38.90
Vangani (borewell)	27.87	55.494	84.63
Nere High School (borewell)	3.83	51.172	96.70
Usurli (abandoned well)	--	51.975	21.1
Shantivan (river)	--	13.079	24.2

vii. Nitrate

Nitrate content was below the range in all the samples (Table 18). The sources of nitrate are usually fertilizer industry waste, solid waste dumps etc. Excess ofnitrate causes blue baby syndrome in human being.

Table 18: Nitrate content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 45 ; IS:10500 Standard: 45			
Ashramshala (handpump)	0.44	0.672	0.28
Ashramshala (well water)	0.255 l	0.392	0.193
New English School (borewell)	0.0065	--	--
Waje School, Waje (borewell)	0.04	0.313	0.015
Usurli (handpump)	0.09	0.260	0.854
Usurli (borewell)	0.04	0.112	0.256
Usurli (borewell)	0.0065	0.297	0.196
Usurli (borewell	0.005	0.135	0.247
Chinchovli (borewell)	0.93	0.176	0.139
Chinchovli (borewell)	0.543	0.383	0.249
Chinchovli (borewell)	0.04	0.589	0.420
Vangani (borewell)	0.416	0.112	0.573
Vangani (borewell)	0.34	0.503	0.643
Vangani (borewell)	BDL	0.058	1.18
Nere High School (borewell)	0.215	0.122	0.961
Usurli (abandoned well)	--	0.769	0.091
Shantivan (river)	--	0.734	0.072

viii. Flouride

Flouride content was within permissible limit as per WHO standard as well as Indian Standard (Table 19) in all the seasons and sites. Excess of fluoride causes fluorosis in human being and animals.

Table 19: Fluoride content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 1.50 ; IS:10500 Standard: 1.0 – 1.2			
Ashramshala (handpump)	0.6	0.6	0.6
Ashramshala (well water)	0.6	0.6	0.6
New English School (borewell)	0.6	--	--
Waje School, Waje (borewell)	0.6	0.6	0.6
Usurli (handpump)	0.6	0.6	0.6
Usurli (borewell)	0.6	0.6	0.6
Usurli (borewell)	0.6	0.6	0.6
Usurli (borewell	0.6	0.6	0.6
Chinchovli (borewell)	0.6	0.6	0.6
Chinchovli (borewell)	0.6	0.6	0.6
Chinchovli (borewell)	0.6	0.6	0.6
Vangani (borewell)	0.6	0.6	0.6
Vangani (borewell)	0.6	0.6	0.6
Vangani (borewell)	0.6	0.6	0.6
Nere High School (borewell)	0.6	0.6	0.6
Usurli (abandoned well)	--	0.6	0.6
Shantivan (river)	--	0.6	0.6

ix. Calcium

It was within permissible limit as per WHO and BIS standard at all the sites in all the seasons (Table 20). In monsoon season calcium content was high in majority of samples. Excess of calcium causes hardness of water.

Table 20: Calcium content ((mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 75 ; IS:10500 Standard: 75			
Ashramshala (handpump)	7.2	2.0	8.543
Ashramshala (well water)	7.4	2.5	7.137
New English School (borewell)	11.1	--	--
Waje School, Waje (borewell)	6.4	2.2	28.14
Usurli (handpump)	11.1	5.2	27.4
Usurli (borewell)	12.4	6.4	39.8
Usurli (borewell)	12.3	6.2	18.34
Usurli (borewell	12.9	6.3	48.32
Chinchovli (borewell)	50.9	4.8	52.8
Chinchovli (borewell)	4.5	6.7	40.4
Chinchovli (borewell)	8.0	6.9	12.07
Vangani (borewell)	49.5	5.1	5.87
Vangani (borewell)	56.1	6.9	32.38
Vangani (borewell)	10.1	8.2	53.4
Nere High School (borewell)	49.5	1.0	44.6
Usurli (abandoned well)	--	7.9	12.0
Shantivan (river)	--	1.40	2.015

x. Magnesium

Magnesium content was within permissible limits (Table 21). It was maximum in monsoon season at all the sites and was in limit as per India and International standards.

Table 21: Magnesium content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 50 ; IS:10500 Standard: 50			
Ashramshala (handpump)	0.4	3.1	9.3
Ashramshala (well water)	21	13.5	9.7
New English School (borewell)	0.19	--	--
Waje School, Waje (borewell)	0.04	0.2	9.9
Usurli (handpump)	0.06	1.99	11.2
Usurli (borewell)	0.12	2.86	9.15
Usurli (borewell)	0.09	2.02	11.4
Usurli (borewell	0.07	1.9	11.6
Chinchovli (borewell)	0.44	2.17	11.8
Chinchovli (borewell)	0.36	7.79	12
Chinchovli (borewell)	20.0	1.54	12.02
Vangani (borewell)	0.49	0.08	12.4
Vangani (borewell)	0.31	1.37	12.6
Vangani (borewell)	0.2	0.19	12.8
Nere High School (borewell)	0.47	12.91	13
Usurli (abandoned well)	--	3.74	13.2
Shantivan (river)	--	13.21	13.6

xi. Micronutrients (Manganese, Zinc, Iron and Copper)

Manganese and Iron content were below detectable limits (Tables 21, 22, 23 and 24) in all the seasons at all the sites. However, zinc and copper were present during monsoon season. Zn content was within permissible limit at all the sites and in all the seasons as per India and International standards (Table 23). While Cu content was above minimum permissible limit in majority of samples (Table 25). As per WHO and Indian Standard copper content upto 1.5 mg/L is relaxed (Annexure).

Table 22: Manganese (mg/L) of drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 0.2 ; IS:10500 Standard: 0.1			
Ashramshala (handpump)	BDL	BDL	BDL
Ashramshala (well water)	BDL	BDL	BDL
New English School (borewell)	BDL	--	--
Waje School, Waje (borewell)	BDL	BDL	BDL
Usurli (handpump)	BDL	BDL	BDL
Usurli (borewell)	BDL	BDL	BDL
Usurli (borewell)	BDL	BDL	BDL
Usurli (borewell	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Nere High School (borewell)	BDL	BDL	BDL
Usurli (abandoned well)	--	BDL	BDL
Shantivan (river)	--	BDL	BDL

Table 23: Zinc content (mg/l) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 5.0 ; IS:10500 Standard: 5.0			
Ashramshala (handpump)	0.167	BDL	0.032
Ashramshala (well water)	0.168	BDL	0.042
New English school (borewell)	BDL	--	--
Vaje school (borewell)	BDL	0.01	0.151
Usurli (handpump)	BDL	BDL	0.01
Usurli (borewell)	BDL	BDL	0.091
Usurli (borewell)	BDL	0.03	0.032
Usurli (borewell	BDL	BDL	0.011
Chinchovli (borewell)	BDL	BDL	0.011
Chinchovli (borewell)	BDL	BDL	0.012
Chinchovli (borewell)	BDL	BDL	0.004
Vangani (borewell)	BDL	BDL	0.007
Vangani (borewell)	BDL	BDL	0.007
Vangani (borewell)	0.127	BDL	0.013
Nere High School (borewell)	BDL	BDL	0.019
Usurli (abandoned well)	--	BDL	0.0054
Shantivan (river)	--	BDL	0.0236

Table 24: Iron content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 0.3 ; IS:10500 Standard: 0.3			
Ashramshala (handpump)	BDL	BDL	BDL
Ashramshala (well water)	0.005	BDL	BDL
New English School (borewell)	0.007	--	--
Waje School, Waje (borewell)	0.01	BDL	BDL
Usurli (handpump)	BDL	BDL	BDL
Usurli (borewell)	0.057	BDL	BDL
Usurli (borewell)	BDL	BDL	BDL
Usurli (borewell	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Chinchovli (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Vangani (borewell)	BDL	BDL	BDL
Nere High School (borewell)	BDL	BDL	BDL
Usurli (abandoned well)	--	BDL	BDL
Shantivan (river)	--	BDL	BDL

Table 25: Copper content (mg/L) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
WHO Standard: 0.05 ; IS:10500 Standard: 0.05			
Ashramshala (handpump)	BDL	BDL	0.00043
Ashramshala (well water)	BDL	BDL	0.021
New English School (borewell)	BDL	--	--
Waje School, Waje (borewell)	BDL	BDL	0.013
Usurli (handpump)	BDL	BDL	0.021
Usurli (borewell)	BDL	BDL	0.048
Usurli (borewell)	BDL	BDL	0.149
Usurli (borewell	BDL	BDL	0.065
Chinchovli (borewell)	BDL	BDL	0.08
Chinchovli (borewell)	BDL	BDL	0.067
Chinchovli (borewell)	BDL	BDL	0.07
Vangani (borewell)	BDL	BDL	0.065
Vangani (borewell)	BDL	BDL	0.078
Vangani (borewell)	BDL	BDL	0.109
Nere High School (borewell)	BDL	BDL	0.1008
Usurli (abandoned well)	--	BDL	0.131
Shantivan (river)	--	BDL	0.105

Microbial Parameters

i. Most Probable Number (MPN) by Multiple Tube Fermentation Method

Microbial analysis of all the samples was carried out by Multiple Tube Fermentation Method and the results were summarized in terms of MPN index. About 40 % samples in post monsoon season, 50% samples in pre monsoon and 88% drinking water samples were found to be contaminated (Table 26; Plates). River sample during pre monsoon was highly contaminated could be due to less water, bathing and washing activities. Some of the borewell samples were highly infected may be due to dirty surrounding or improper handling of borewells. Overall high microbial density in monsoon season could be due to mixing of runoff water containing wastes etc.

Table 26 : Most Probable Number (MPN) in drinking water samples from selected sites during different seasons

Location	Post Monsoon	Pre Monsoon	Monsoon
	MPN Index	MPN Index	MPN Index
WHO: Fecal Coliform - 0 cells/100 mL; Relaxed Standard- 1- 10 cells/100ml; IS:10500 Standard: 1-10			
Ashramshala (handpump)	Nil	Nil	49
Ashramshala (well water)	27	14	Nil
New English School (borewell)	Nil	--	--
Waje School, Waje (borewell)	2	34	7
Usurli (handpump)	Nil	Nil	70
Usurli (borewell)	Nil	2	70
Usurli (borewell)	6	120	49
Usurli (borewell	1600	Nil	>2400
Chinchovli (borewell)	Nil	Nil	Nil
Chinchovli (borewell)	Nil	Nil	49
Chinchovli (borewell)	Nil	Nil	350
Vangani (borewell)	Nil	15	>2400
Vangani (borewell)	2	Nil	5
Vangani (borewell)	4	2	23
Nere High School (borewell)	Nil	5	220
Usurli (abandoned well)	--	Nil	>2,400
Shantivan (river)	-- --	1600	4

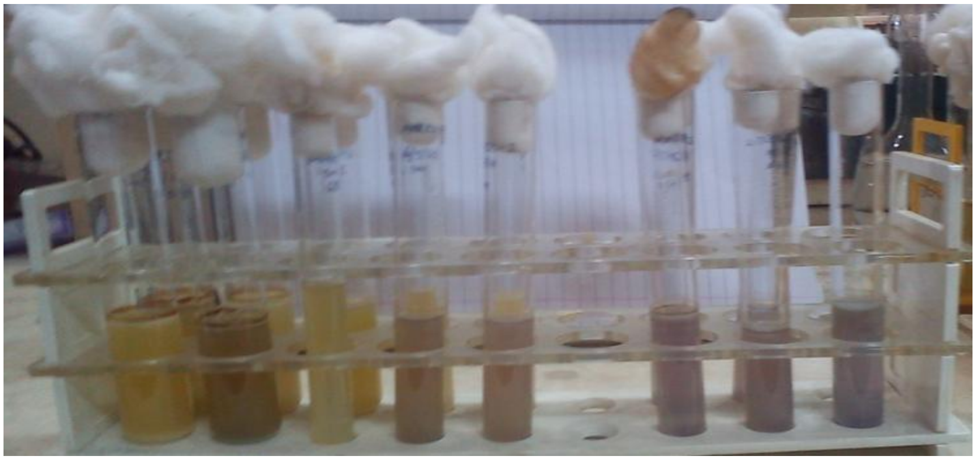


Plate 7: Sample MMREIS- 009 showing acid and gas production in 4 double strength and 3 Single strength tubes

Plate 8: Sample MMREIS 011 only one tube showing acid and gas production

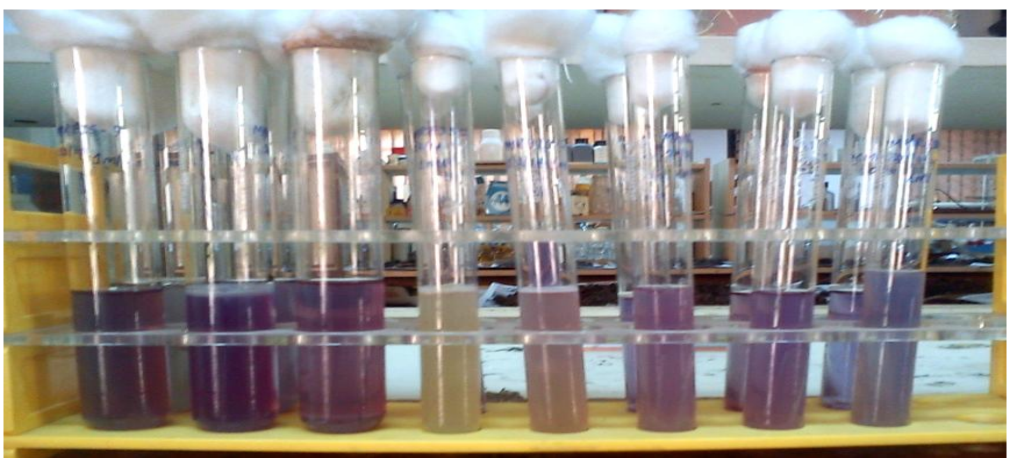


Plate 9: Sample MMREIS 014 showing gas and acid production in two single strength tube

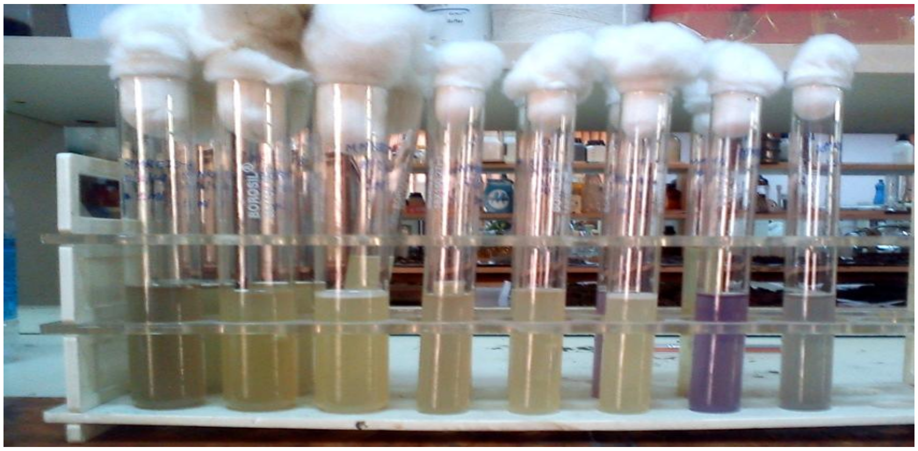


Plate 10: Sample MMREIS 015 showing acid and gas production in 5 double strength and 9 single strength tubes

Plate 11: Sample MMREIS 020 - Acid and gas production only in 1 single strength tube

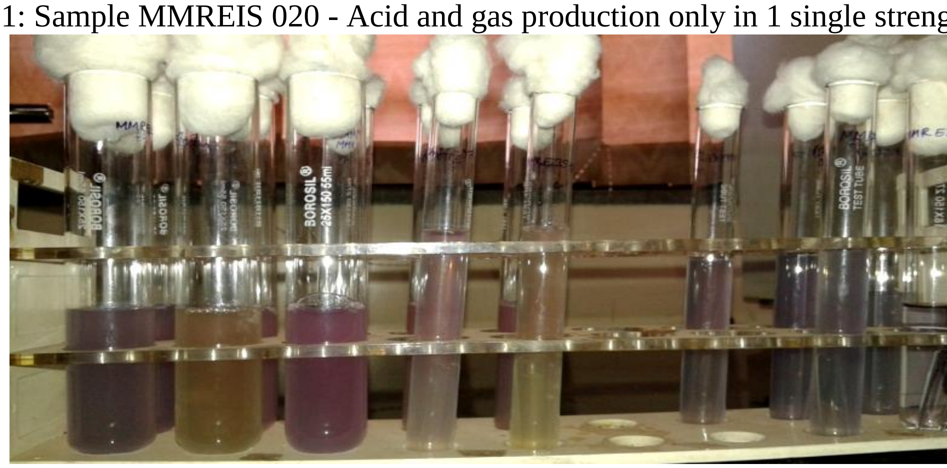


Plate 12: Sample MMREIS 021 showing Acid and gas production in one double strength and one single strength tube

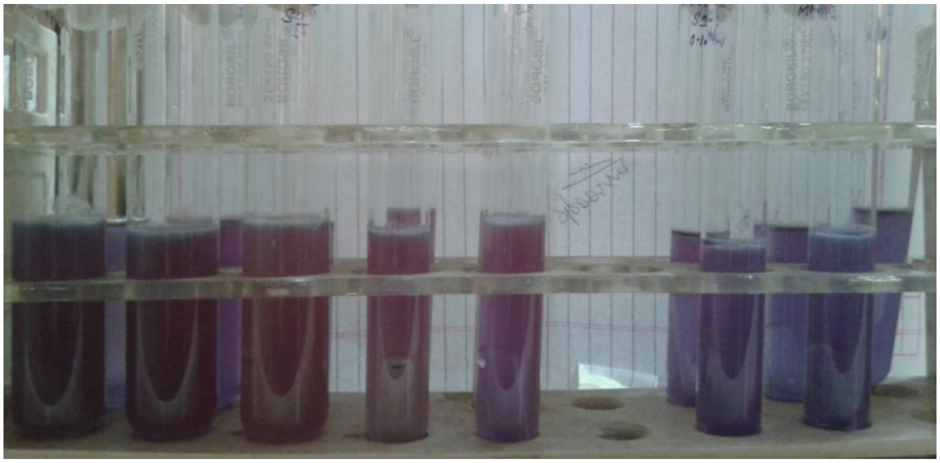


Plate 13: Sample MMREIS 024 showing acid and gas production in double strength and single strength tubes

Plate 14: Sample MMREIS 025 showing acid and gas production in double strength and single strength tubes

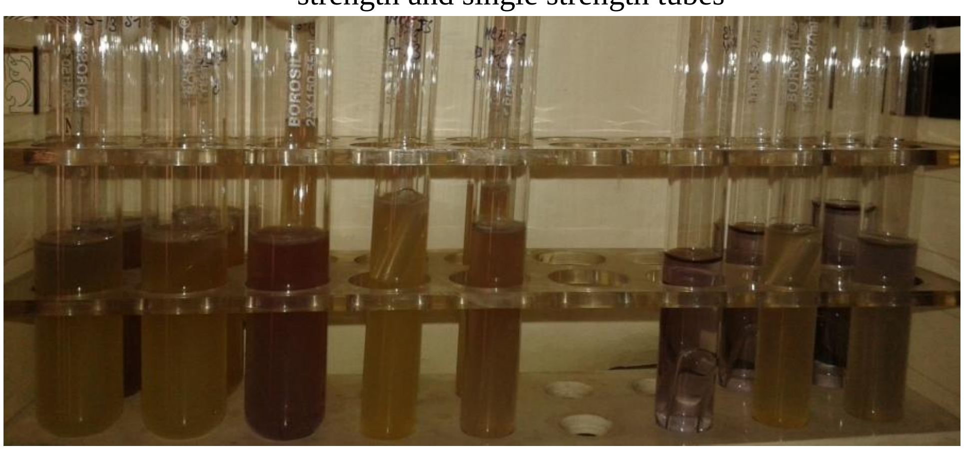


Plate 15: MMREIS 028 Acid and gas production in 5 double strength and 5 single strength tubes

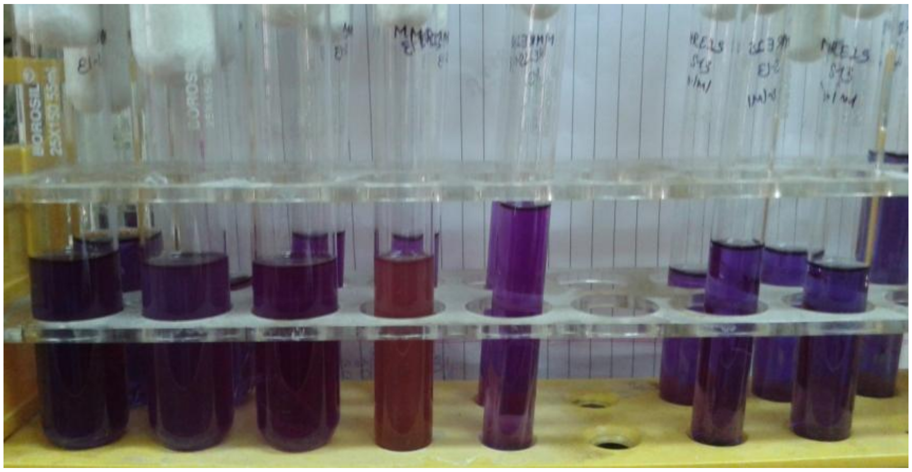


Plate 16: Sample MMREIS 027 acid and gas production in 1 tube

Plate 17: Sample MMREIS 036 Acid and gas production in 2 double strength tubes

Plate 18: Sample MMREIS 033 showing acid and gas production in 2 double and 4 single strength tubes

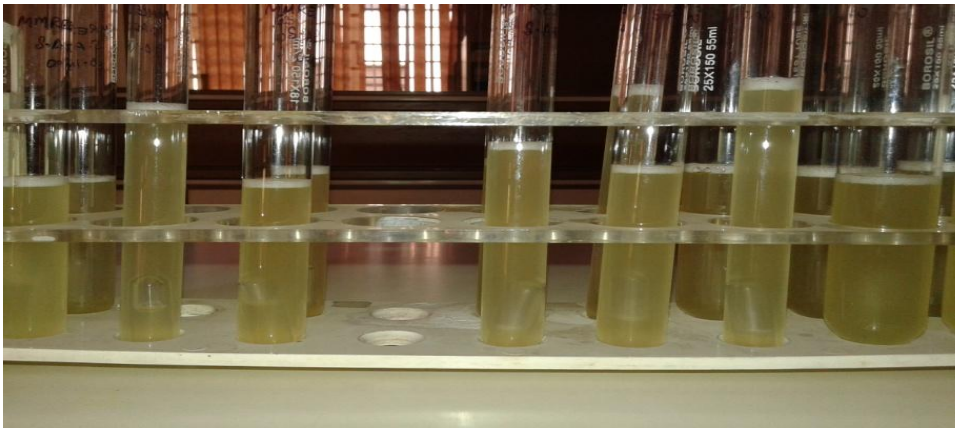


Plate 19: Sample MMREIS 038 showing acid and gas production in all tubes

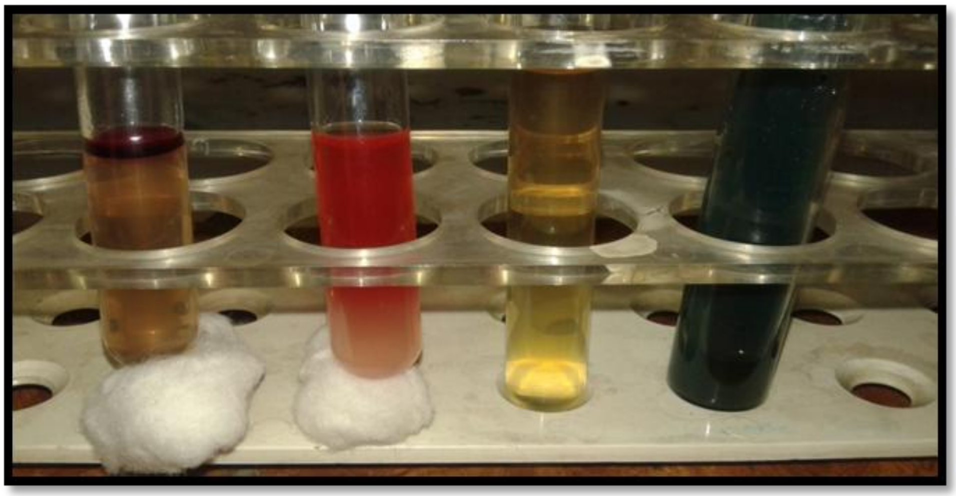


Plate 20: Imvic test positive for *E. coli*

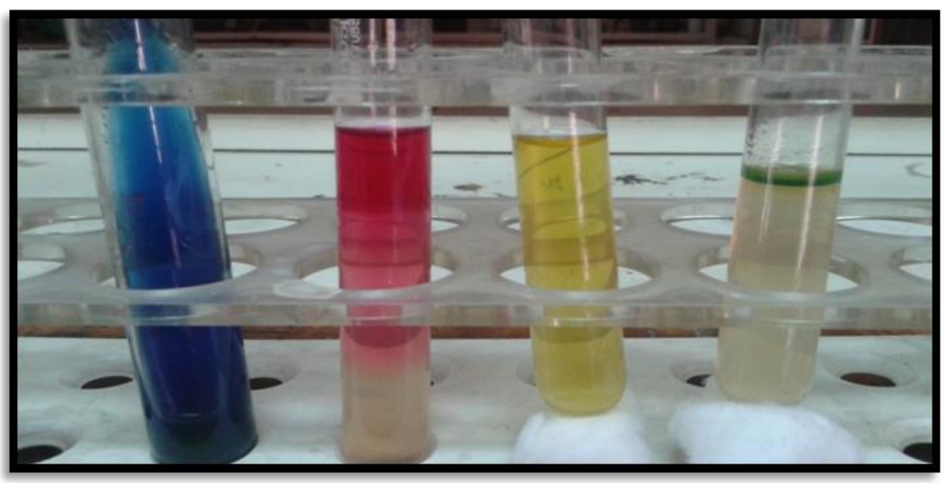


Plate 21: Imvic test positive for *Klabsiella sp.*

IMViC Test for the Identification of Bacteria

The test confirmed that maximum samples were contaminated by *E. coli* followed by *Klabsiella* sp (Table 27; Plates 21 &22). It confirms that drinking water samples were infected by fecal coliforms. All the 16 isolates of *E.coli* had given positive test for Indole, methyl-red test, catalase and for lactose fermenting, and negative biochemical test are Voges-Proskuaer and citrate. Further, by gram staining it was confirmed (Plates-25 to 30). While 14 samples confirmed for *Klabsiella* sp. had given positive test for Voges Proskauer and Citrate test (Table 5).

Table 27: Microbial colonies observed in contaminated water samples

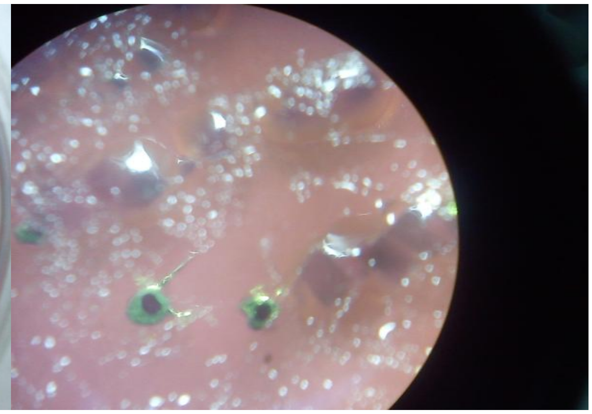
Sample No.	Colonies Observed
MMREIS009	*E.coli.*
MMREIS011	*Klebsiella, E.coli.*
MMREIS014	*Klebshiella*
MMREIS015	*E.coli.*
MMREIS020	*Klebsiella*
MMREIS021	*E.coli.*
MMREIS024	*E.coli,.Klebsiella*
MMREIS025	*E.coli.*
MMREIS028	*Klebsiella*
MMREIS 027	*E.coli.*
MMREIS 033	*Klebsiella*
MMREIS035	*Klebsiella*
MMREIS036	*Klebsiella*
MMREIS038	*E.coli. Klebsiella*
MMREIS039	*Kelbsiella*
MMREIS040	*E. coli*
MMREIS041	*Kelbsiella*
MMREIS042	*E. coli*
MMREIS043	*Entrobacter*
MMREIS044	*E. coli, Kelbsiella*
MMREIS045	*E. coli, Kelbsiella*
MMREIS046	ND
MMREIS047	*E. coli*
MMREIS048	*E. coli*
MMREIS049	*E. coli, Kelbhiella*
MMREIS050	*Entrobacter*
MMREIS051	*Kelbsiella*
MMREIS052	*E. coli*

ND- Not Detected

Plate 22: H_2S test Results (Post Monsoon)

Plate 23: H_2S test Results (Pre Monsoon)

Plate 24: H_2S test Results (Monsoon)

Plates 25 & 26: Sample MMREIS 011 and MMREIS 009 showing green metallic sheen colonies

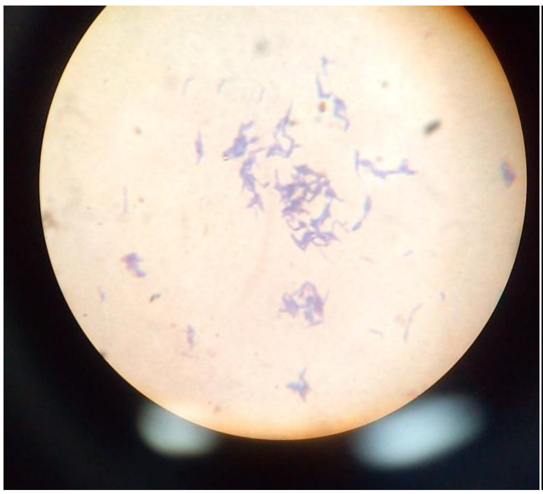


Plate 27: Gram positvie colonies

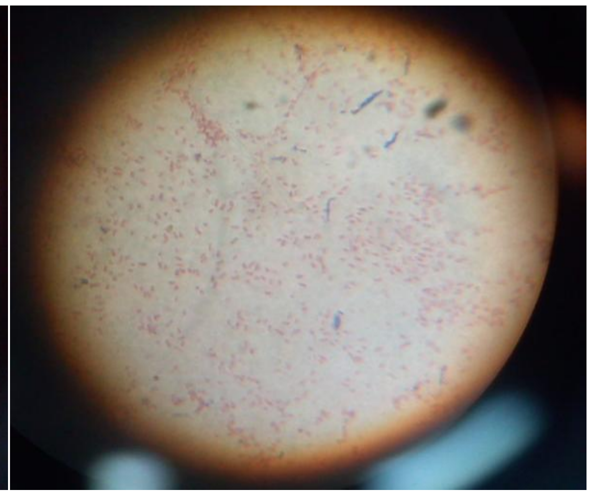


Plate 28 Gram negative colonies

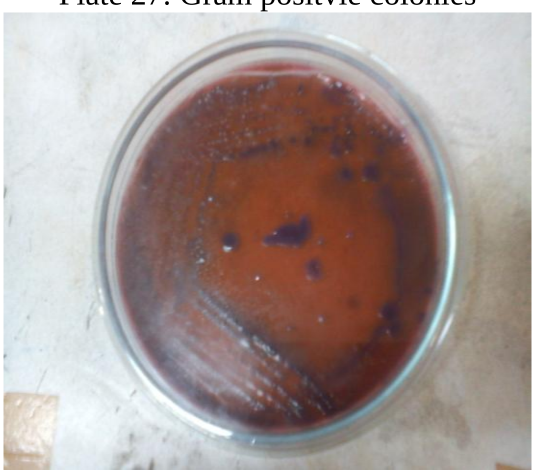


Plate 29: Showing purple opaque colonies

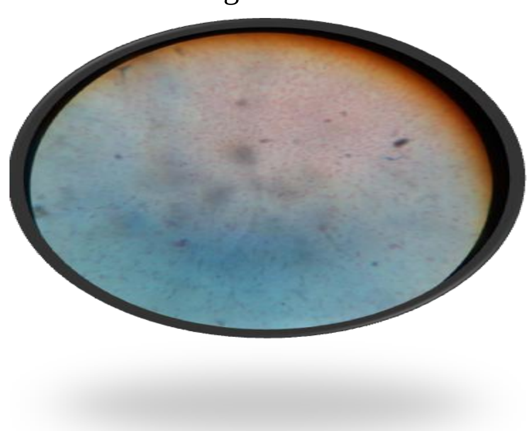


Plate 30: Showing gram negative bacteria

H_2S Paper Test for the Identification of Fecal Contamination

As noted from table no. 28 and plates 22 to 24, a color change indicates the presence of bacteria of fecal origin. The speed of the reaction will determine the density of organisms present; i.e. the quicker the reaction the higher the number of fecal organisms presence. This can also be interpreted in terms of a risk factor. For example, a slight color change (+) on day three indicates a lesser risk than a strong (+++) change on day 1. In monsoon season intensity of infection was more in comparison to other seasons (Table 28).

On getting positive H_2S test results, various household disinfection techniques could be recommended to stakeholders such as boiling, adding a few drops of chlorine bleach (4 drops per litre), and/or putting the water in a clear plastic bottle and exposing it to full sunlight for a minimum of 4 hours.

Table 28: Hydrogen sulphide test for contaminated water samples

SAMPLE No.	Day 1	Day 2	Day 3
MMREIS 009	-	+	++
MMREIS 013	-	-	+
MMREIS 014	+++	+++	+++
MMREIS 016	-	-	+
MMREIS 019	-	-	+
MMREIS 020	-	-	+
MMREIS 024	-	-	+
MMREIS 025	-	+	+
MMREIS 028	-	+	++
MMREIS 033	-	+	+
MMREIS 038	+++	+++	+++
MMREIS 039	-	-	-
MMREIS 040	-	-	+
MMREIS 041	-	-	++
MMREIS 042	-	-	-
MMREIS 043	-	-	+
MMREIS 044	-	++	+++
MMREIS 045	-	++	+++
MMREIS 046	-	-	+
MMREIS 047	+	++	+++
MMREIS 048	+	++	+++
MMREIS 049	+	+++	+++
MMREIS 050	-	+	+
MMREIS 051	+	+	++
MMREIS 052	+	+++	+++
MMREIS 053	+	++	+++
MMREIS 054	+	+++	+++

(–) = no change; (+) = slight change, the paper strip or water has turned gray;
(++) = the paper strip is partially black; (+++) = the strip and the water sample itself are noticeably black.

3. Disinfection of Contaminated Water Samples

The drinking water samples found positive in MPN for microbial contamination were further utilized for disinfection studies. Low cost disinfection techniques viz. boiling, chlorination and solar disinfection (SODIS) were exploited to evaluate the potential of techniques as well as to propagate improved methods in selected areas.

Boiling: Samples collected at different time duration at the boiling as well after boiling (control, 5 min., 10 min., 20 min. and 30 min.) were plated on standard media to evaluate the best time duration after boiling for disinfection. It was observed that water samples were completely disinfected even in control as well as at 5 min. of rolling boil in all the seasons and samples (Table 29 - 31). WHO (2002) had also reported 5 -10 minutes of rolling boil of water at 60˚C is sufficient to kill pathogens viz. bacteria, virus, protozoa etc.

Table 29: Disinfection by boiling of contaminated water samples (Post Monsoon)
Temperature; 80^0C

Sample No.	(CFU/ml) with time of exposure after the start of boiling					
	Original sample	Control	5 min.	10 min.	20 min.	30 min.
MMREIS 009	2.7×10^4	Nil	Nil	Nil	Nil	Nil
MMREIS 013	2.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 014	6.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 016	1.6×10^5	Nil	Nil	Nil	Nil	Nil
MMREIS 019	2.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 020	4.0×10^3	Nil	Nil	Nil	Nil	Nil

Table 30: Disinfection by boiling of contaminated water samples (Pre Monsoon)
Temperature; 80^0C

Sample No.	(CFU/ml) with time of exposure after the start of boiling					
	Original sample	Control	5 min.	10 min.	20 min.	30 min.
MMREIS 024	1.4×10^4	Nil	Nil	Nil	Nil	Nil
MMREIS 025	3.4×10^4	Nil	Nil	Nil	Nil	Nil
MMREIS 027	1.2×10^5	Nil	Nil	Nil	Nil	Nil
MMREIS 028	2.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 033	1.5×10^4	Nil	Nil	Nil	Nil	Nil
MMREIS 034	2.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 036	5.0×10^3	Nil	Nil	Nil	Nil	Nil
MMREIS 038	1600	Nil	Nil	Nil	Nil	Nil

Table 31: Disinfection by boiling of contaminated water samples (Monsoon)
Temperature; 80^0C

Sample No.		(CFU/ml) with time of exposure				
	Original sample	**Control**	**5 min.**	**10 min.**	**20 min.**	**30 min.**
MMERIS040	3.6×10^5	Nil	Nil	Nil	Nil	Nil
MMERIS041	1.6×10^5	Nil	Nil	Nil	Nil	Nil
MMERIS043	1.5×10^5	Nil	Nil	Nil	Nil	Nil
MMERIS 044	confluent growth	Nil	Nil	Nil	Nil	Nil
MMERIS 049	1.0×10^5	Nil	Nil	Nil	Nil	Nil
MMERIS 050	$9. \times 10^6$	Nil	Nil	Nil	Nil	Nil
MMERIS 052	2×10^6	Nil	Nil	Nil	Nil	Nil
MMERIS 053	8.0×10^5	Nil	Nil	Nil	Nil	Nil

Table 32: Chlorine disinfection of contaminated water samples (Post Monsoon)

Sample No.	(CFU/ml) with time of exposure				
	Original sample	**Conc. Of Chlorine (%)**	**10 min.**	**15 min.**	**20 min.**
MMREIS 009	2.7×10^4	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 013	2.0×10^3	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 014	6.0×10^3	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 016	1.6×10^5	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 019	2.0×10^3	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 020	4.0×10^3	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil

Chlorination: The sodium hypochlorite drops in the range of 1- 4% were found to be effective in controlling microbial contamination (Table 33 to 35) at minimum (10 min.) as well as maximum (20 min.) time duration in different seasons. It could be due to low level of microbial cells in the samples. As per toxicological studies of sodium hypochlorite on rats, above 4% sodium chlorite may cause toxic effect with symptoms of asthma and dermatitis (Anonymous, 1992).

Table 33: Chlorine disinfection of contaminated water samples (Pre Monsoon)

Sample No.	(CFU/ml) with time of exposure				
	Original sample	**Conc. of Chlorine (%)**	**10 min.**	**15 min.**	**20 min.**
MMREIS 024	$1.4x10^4$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 025	$3.4x10^4$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 027	$1.2x10^5$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 028	$2.0 x10^3$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 033	$1.5x10^4$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 034	$2.0x10^3$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 036	$5.0x10^3$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil
MMREIS 038	$1.6x10^5$	1	Nil	Nil	Nil
		2	Nil	Nil	Nil
		4	Nil	Nil	Nil

Table 34: Chlorine disinfection of contaminated water samples (Monsoon)

Sample No.		(CFU/ml) with time of exposure			
	Original sample	Conc. Of Chlorine	10 min.	15 min.	20 min.
MMERIS040	$3.6x10^5$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS041	$1.6x10^5$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS043	$9.0x10^5$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS 044	$8.0 x10^5$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS 049	$1.0x10^6$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS 050	$2.0x10^6$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS 052	confluent growth	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil
MMERIS 053	$1.5x10^5$	1%	Nil	Nil	Nil
		2%	Nil	Nil	Nil
		4%	Nil	Nil	Nil

Solar Disinfection: Table 35 shows that the maximum light intensity reached 720 W/m^2 in post monsoon season followed by 695 W/m2 and 512 W/m2 in pre monsoon and post monsoon seasons, respectively, which was much more than the recommended 500 W/m^2 for effectiveness of SODIS (Wegelin et al., 1994). The temperature ranged from 41˚C to 37.5˚ C. It is apparent from the table 35 that all the organisms were completely killed at low as well as high exposure to light in all the seasons. Total disinfection even at 30 minutes of sunlight exposure could be due to low density of microbes in samples.

Table 35: Solar disinfection of contaminated drinking water samples in different seasons

Season, Avg. Light intensity and Temperature	Sample No.	(CFU/ml) with time of exposure				
		original sample	30 min.	1 hour	2 hours	4 hours
Post Monsoon (720 W/m^2; 38.5˚C)	MMREIS 009	1.4x 10^4	Nil	Nil	Nil	Nil
	MMREIS 013	3.4x 10^4	Nil	Nil	Nil	Nil
	MMREIS 014	1.2x 10^5	Nil	Nil	Nil	Nil
	MMREIS 016	2.0 x10^3	Nil	Nil	Nil	Nil
	MMREIS 019	1.5x 104	Nil	Nil	Nil	Nil
	MMREIS 020	2.0 x10^3	Nil	Nil	Nil	Nil
Pre Monsoon (695 W/m^2; 41˚C)	MMREIS 024	5.0 x10^3	Nil	Nil	Nil	Nil
	MMREIS 025	1.6 x10^5	Nil	Nil	Nil	Nil
	MMREIS 027	2.7 x10^4	Nil	Nil	Nil	Nil
	MMREIS 028	2.0 x 10^3	Nil	Nil	Nil	Nil
	MMREIS 033	6.0 x 10^3	Nil	Nil	Nil	Nil
	MMREIS 034	1.6x 10^5	Nil	Nil	Nil	Nil
	MMREIS 036	2.0 x10^3	Nil	Nil	Nil	Nil
	MMREIS 038	4.0 x 10^3	Nil	Nil	Nil	Nil
Monsoon (512 W/m^2; 37.5˚C)	MMERIS 040	3.6 x10^5	Nil	Nil	Nil	Nil
	MMERIS 041	1.6x10^5	Nil	Nil	Nil	Nil
	MMERIS 043	1.5x10^5	Nil	Nil	Nil	Nil
	MMERIS 044	confluent growth	Nil	Nil	Nil	Nil
	MMERIS 049	1.0x10^5	Nil	Nil	Nil	Nil
	MMERIS 050	9.x10^6	Nil	Nil	Nil	Nil
	MMERIS 052	2x10^6	Nil	Nil	Nil	Nil
	MMERIS 053	8.0x10^5	Nil	Nil	Nil	Nil

Plate 31: Solar disinfection **Plate 32: Disinfection by boiling**

4. Awareness Programme on Drinking Water in Villages and Schools

Awareness generation programmes were conducted in selected areas to dissemination knowledge on the management of important resource. Apart from audio- visual aides, posters were displayed and pamphlets were distributed to stakeholders consisting on students, villagers and participants fro local NGOs. Five awareness generation programmes on drinking water contamination and low cost purification were conducted at the following places.

1. Waje High School, Waje, Panvel
2. Nere High School, Nere, Panvel
3. Anna Bhau Sahasrabudhe Anudanit Ashramshala, Shanthivan, Wakadi, Panvel
4. Balwantrai Mehta Panchayatiraj Jagruti Kendra Shantivan, Panvel
5. SIES Educational Complex, Nerul

Awareness Programme- No. 1

Participants: Students of class VIII and IX and teachers from Waje High School, Waje, Panvel

Total Number of students: 30

Date: 24th March 2014

Table 36: Participants' response to awareness programme- Waje High School, Waje

Question .No.	Pre- Awareness Programme response	Post-awarenss programme response
1 Sea water is not potable because	Out of 30 students 2 students said it is dirty while 28 students said that it is salty.	Out of 30 students 24 students said that it is salty six students said that the dissolved salts are harmful to health.
2 Could drinking water cause diseases?	Out of 30 students 22 said yes while 8 said no.	Out of 30 students 30 said yes
3 Could the quality of drinking water be ascertained by its appearance?	Out of 30 students all the 30 students said yes	Out of 30 students 21 said yes while nine said no.
4 Could the quality of drinking water ascertained by its taste?	Out of 30 students all the 30 students said yes	Out of 30 students 18 said yes while 12 said no.
5 The same water could be	Out of 30 students all the 30 students said	Out of 30 students 19 said yes

used for drinking, cooking and washing?	yes	while six said need not be and 5 said no.
6 Can you name some diseases caused due to contaminated water? If yes name them	Out of 30 students all the 30 students said yes Cholera and Jaundice were mentioned.	Out of 30 students all the 30 students said yes Cholera and Jaundice were mentioned
7 Toilet can be located	Out of 30 students all the 30 students said that it needs to be located far away from drinking water bore well.	Out of 30 students all the 30 students said that it needs to be located far away from drinking water bore well.
8 Do you know what parameters are tested for checking the potability of water? Name them	None of the students could correctly name them.	Out of 30 students 10 said bacteria and 11 said salts and 4 said pH and 5 said chlorine
9 Is simple filtration enough to make water safe to drink?	Out of 30 students all said that it is enough	Out of 30 students 18 said that it is enough while 12 said that it is not enough
10 Is boiling water make it safe to drink?	Out of 30 students all said yes.	Out of 30 students 21 said yes and nine said not necessarily.
11 Chlorine is added to drinking water to	Out of 30 students 14 said that it is to kill bacteria and 16 said that it is to remove dirt.	Out of 30 students 23 said that it is to kill bacteria and 7 still said that it is to remove dirt.
12 Keeping drinking water in transparent plastic bottles in hot sun for four hours makes it safer to drink	Out of 30 students all said no.	Out of 30 students 17 said yes while 13 said no.

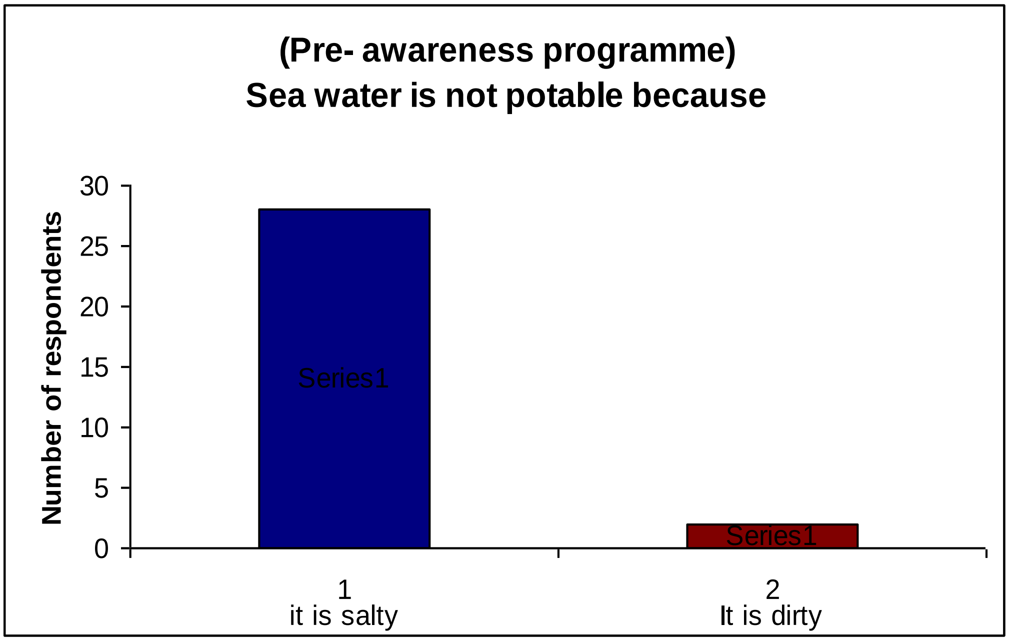


Figure 26: Pre-awareness knowledge on potability of sea water
Out of 30 students 2 students said it is dirty while 28 students said that it is salty.

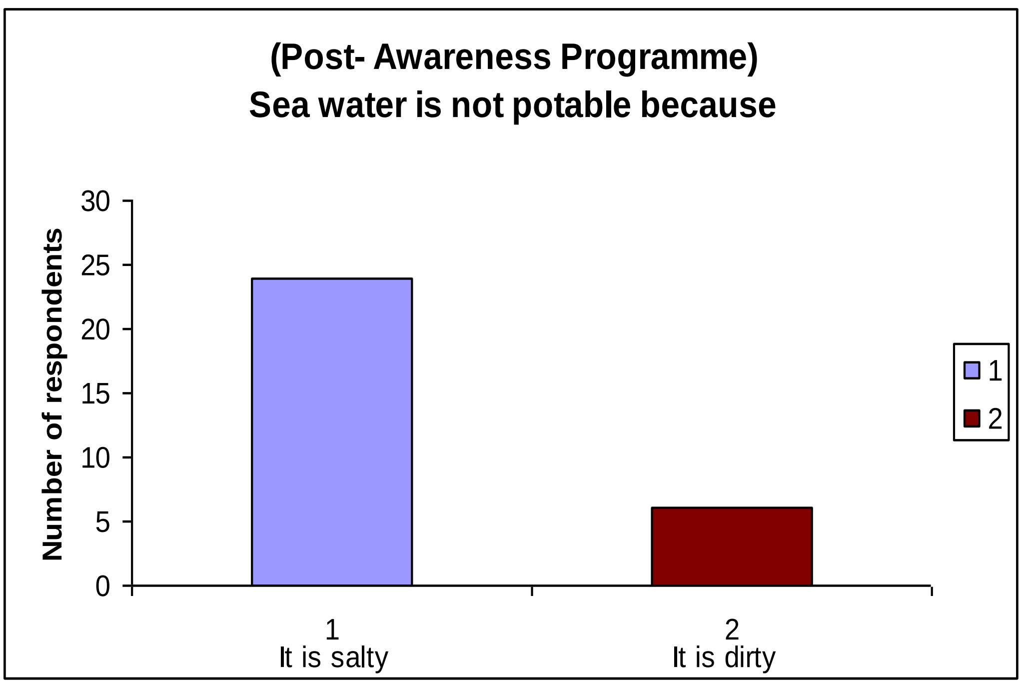


Figure 27: Post awareness knowledhge on potability of sea water
Out of 30 students 24 students said that it is salty six students said that the dissolved salts are harmful to health.

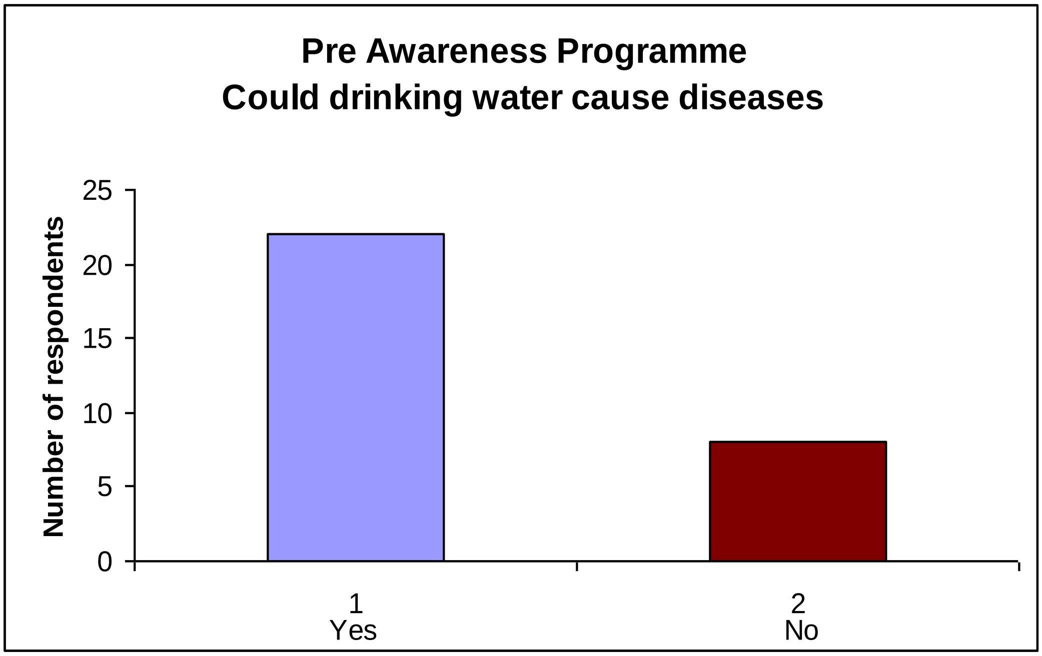


Figure 28: Pre awareness knowledge on drinking water and diseases
Out of 30 students 22 said yes while 8 said no.

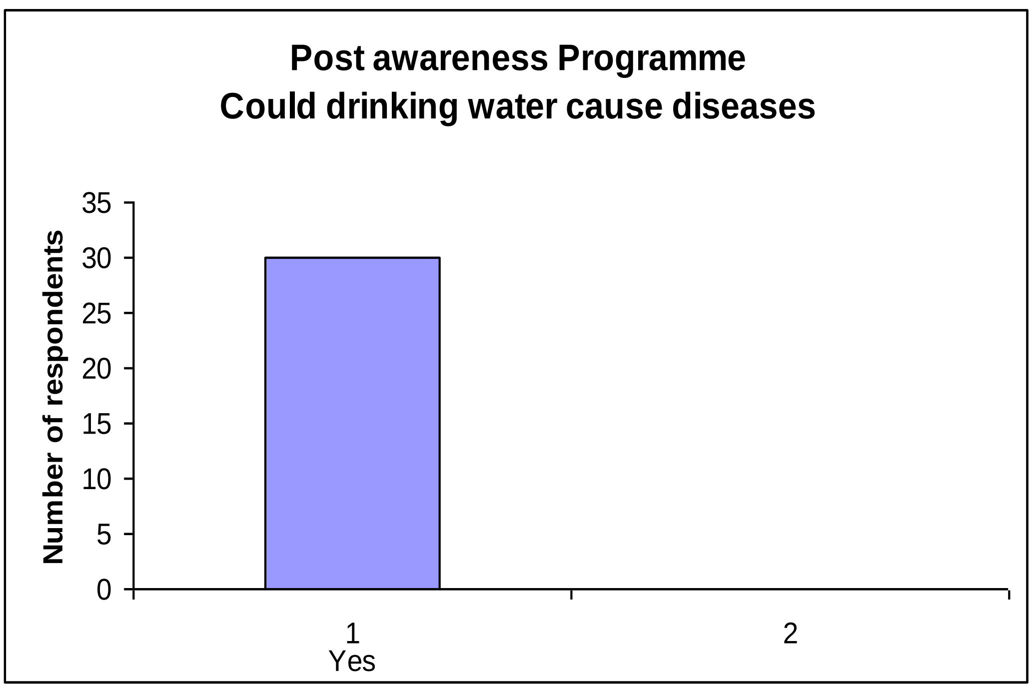


Figure 29: Post awareness knowledge on drinking water and diseases
Out of 30 students all 30 students said yes

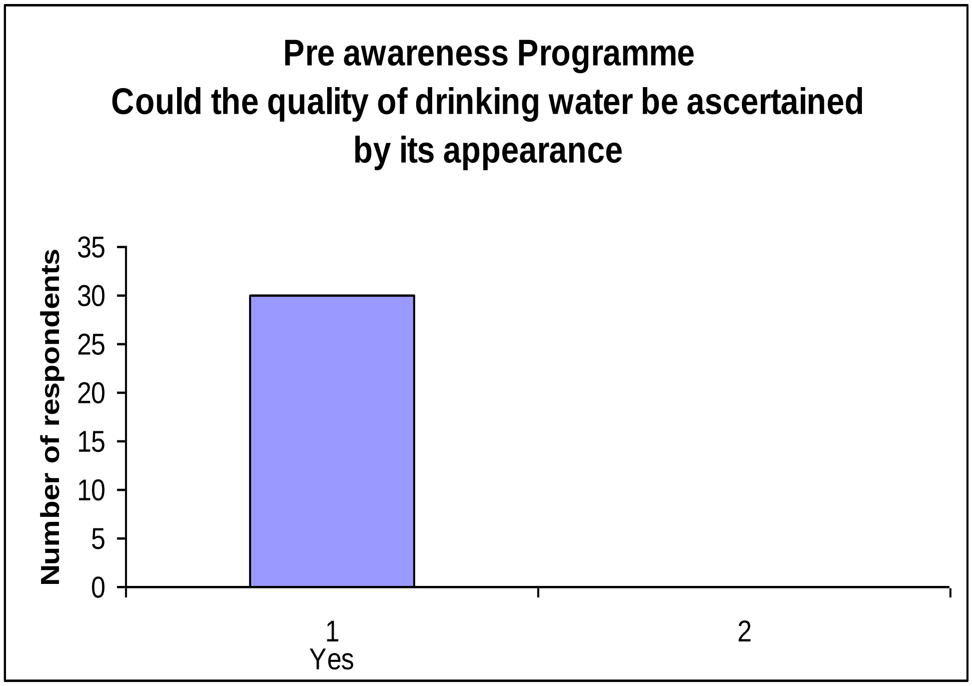


Figure 30: Pre awareness knowledge on assessment of quality of drinking water
Out of 30 students all 30 students said yes

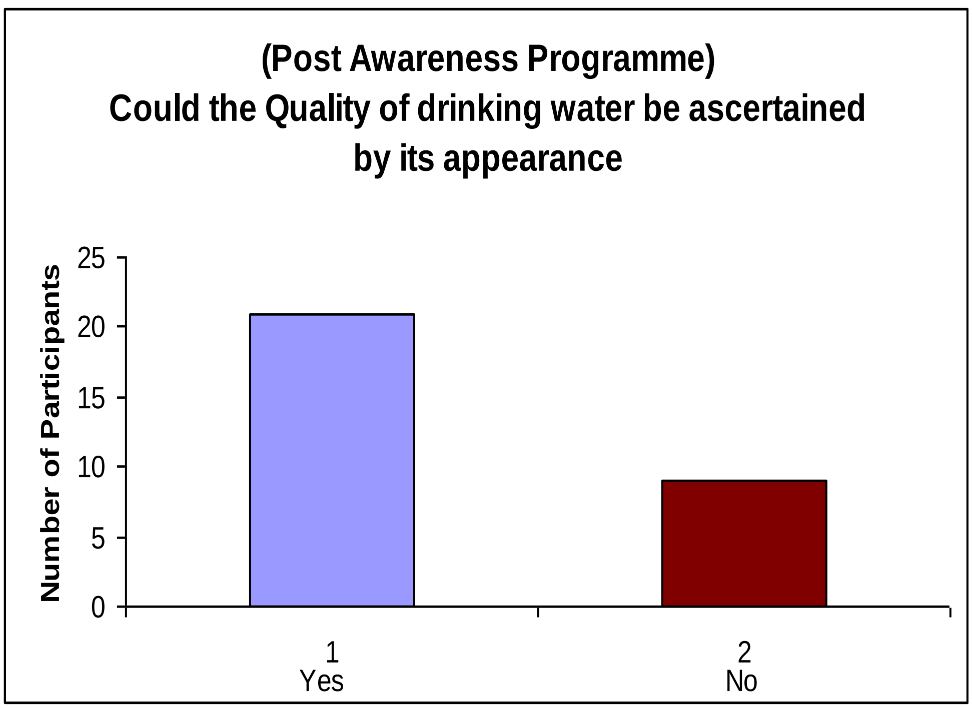


Figure 31: Post awareness knowledge on assessment of quality of drinking water
Out of 30 students 21 said yes while nine said no

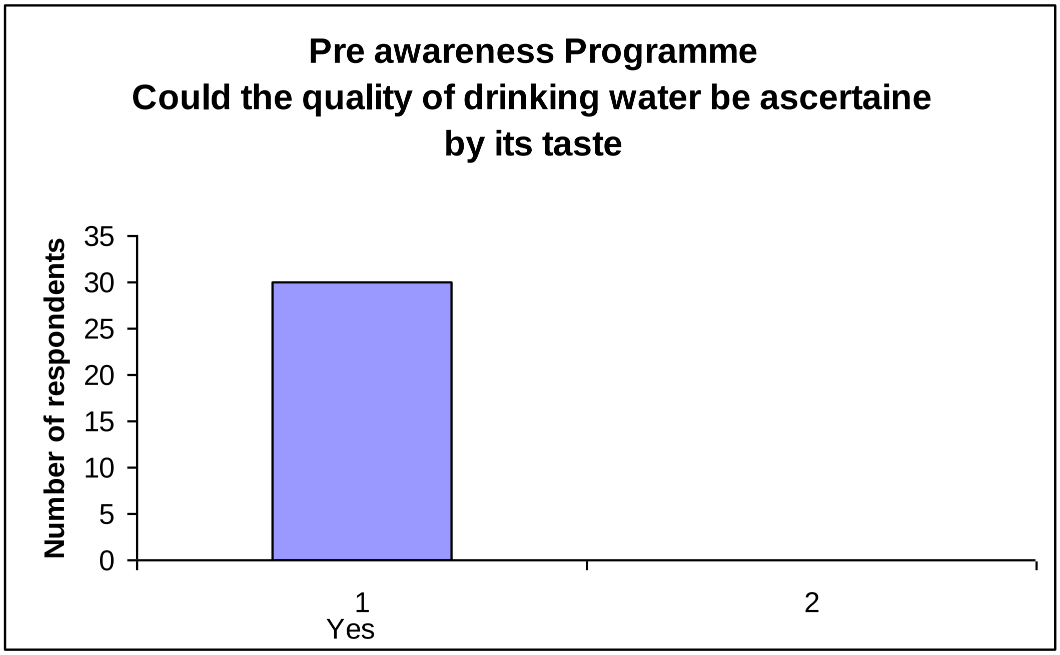


Figure 32: Pre awareness knowledge on assessment of quality of drinking water by taste

Out of 30 students all the 30 students said yes

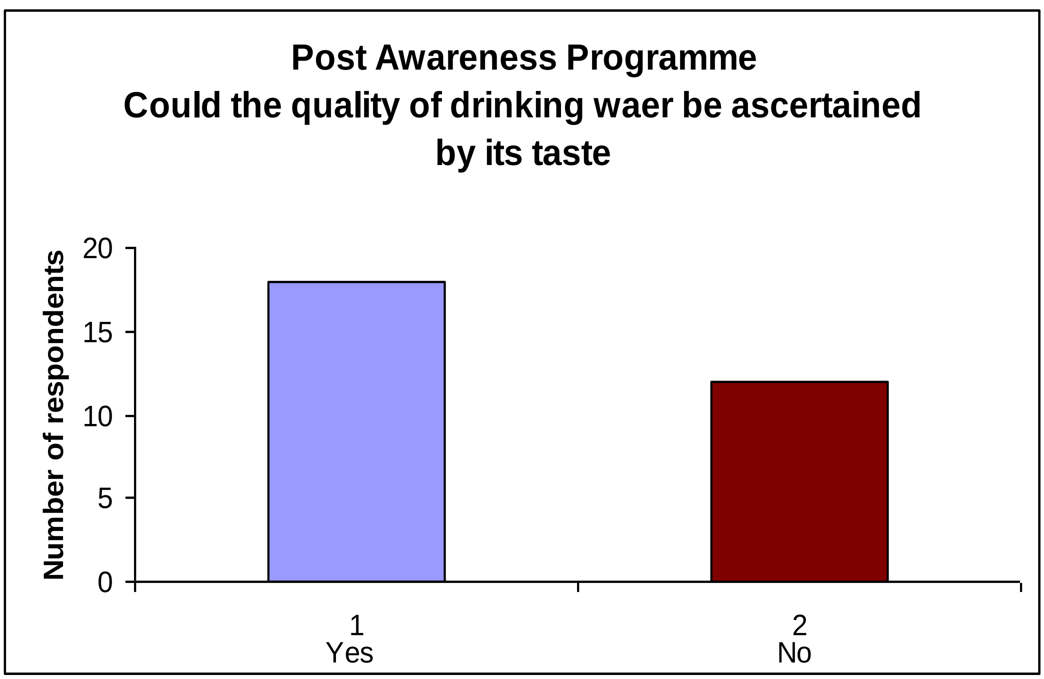


Figure 33: Post awareness knowledge on assessment of quality of drinking water by taste

Out of 30 students 18 said yes while 12 said no

Plate 33: Inauguration of Drinking water Awareness campaign at Waje High School, Waje on 24th March 2014

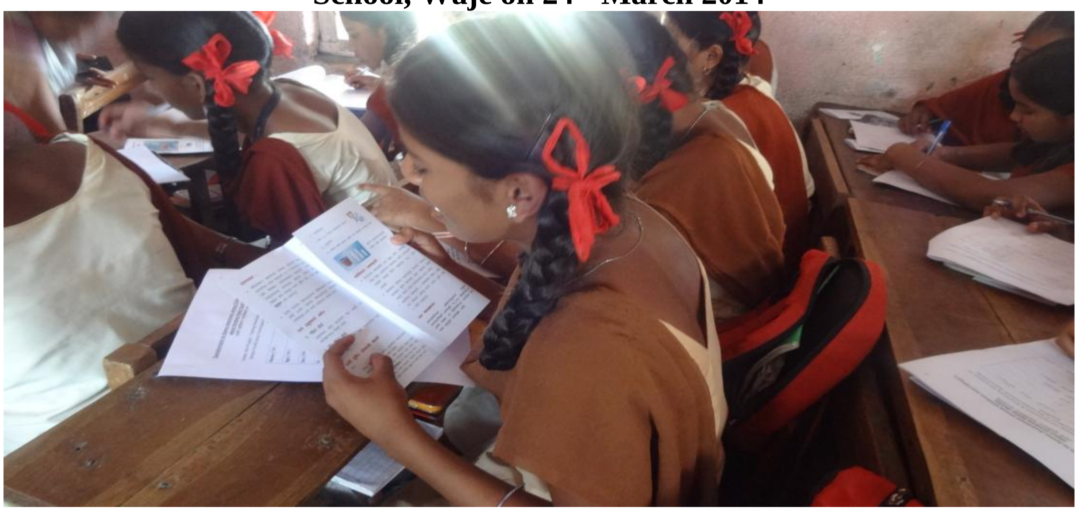


Plate 34: Students reading the pamphlets

Plate 35: Posters displayed at Waje High School, Waje programme

Plate 36: Project team member discussion with students at Waje High School, Waje, Panvel

Plate 37: Attention of students in lectures cum demonstration at Waje High School, Waje, Panvel

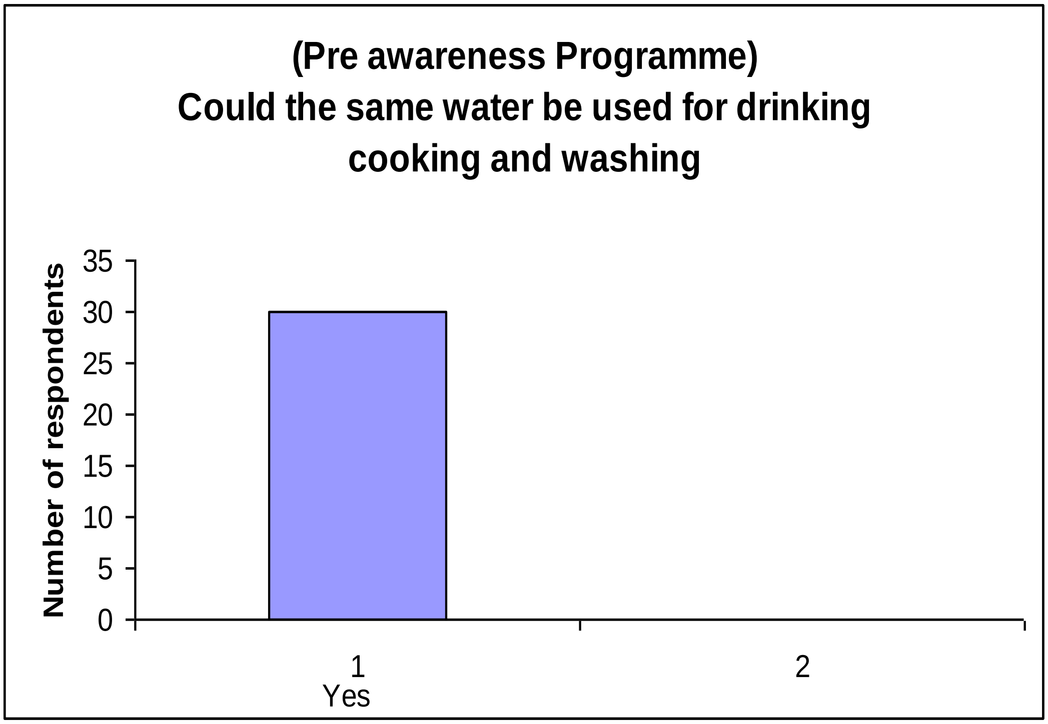


Figure 34: Pre awareness knowledge on use of drinking water for cooking and washing

Out of 30 students all the 30 students said yes

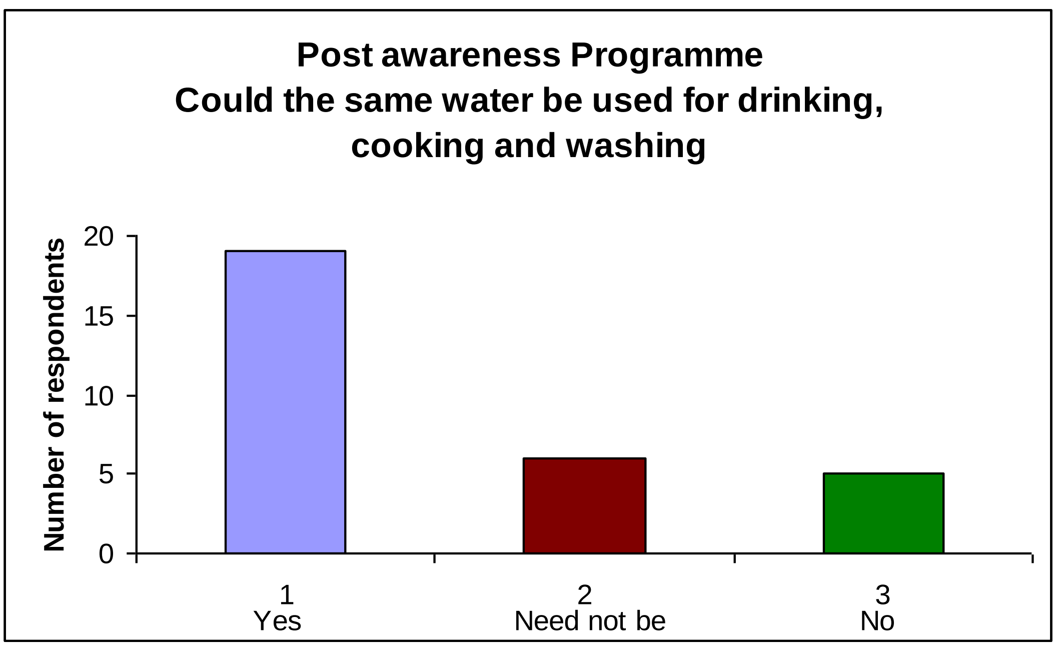


Figure 35: Post awareness knowledge on use of drinking water for cooking and washing

Out of 30 students 19 said yes while six said need not be and 5 said no.

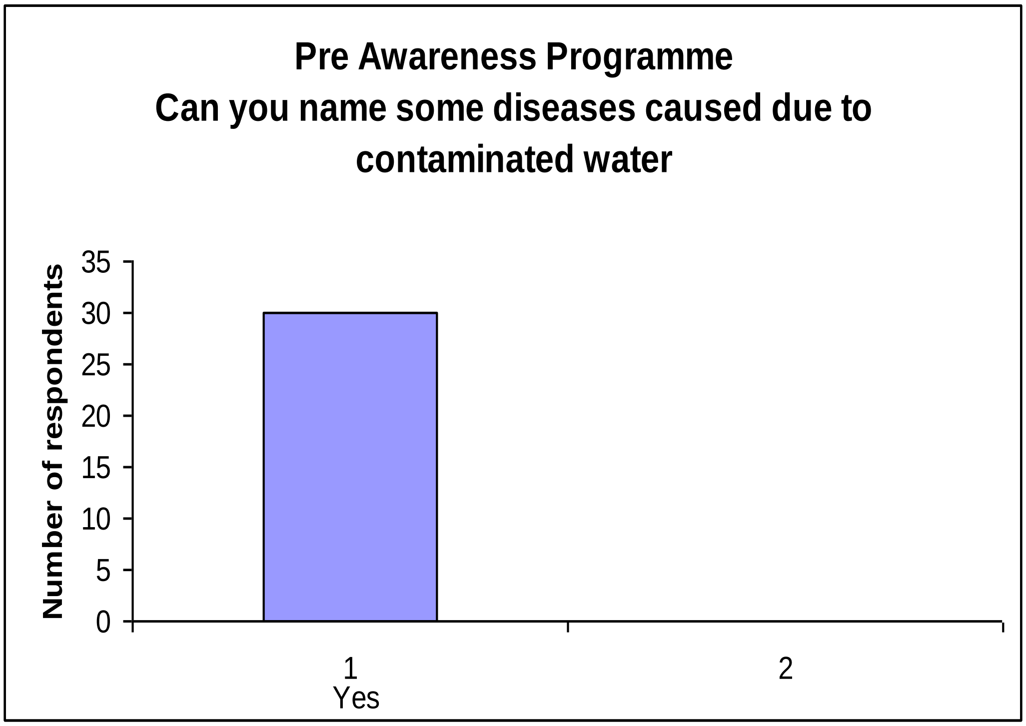


Figure 36: Pre awareness knowledge on ability to name a few water borne diseases
Out of 30 students all the 30 students said yes

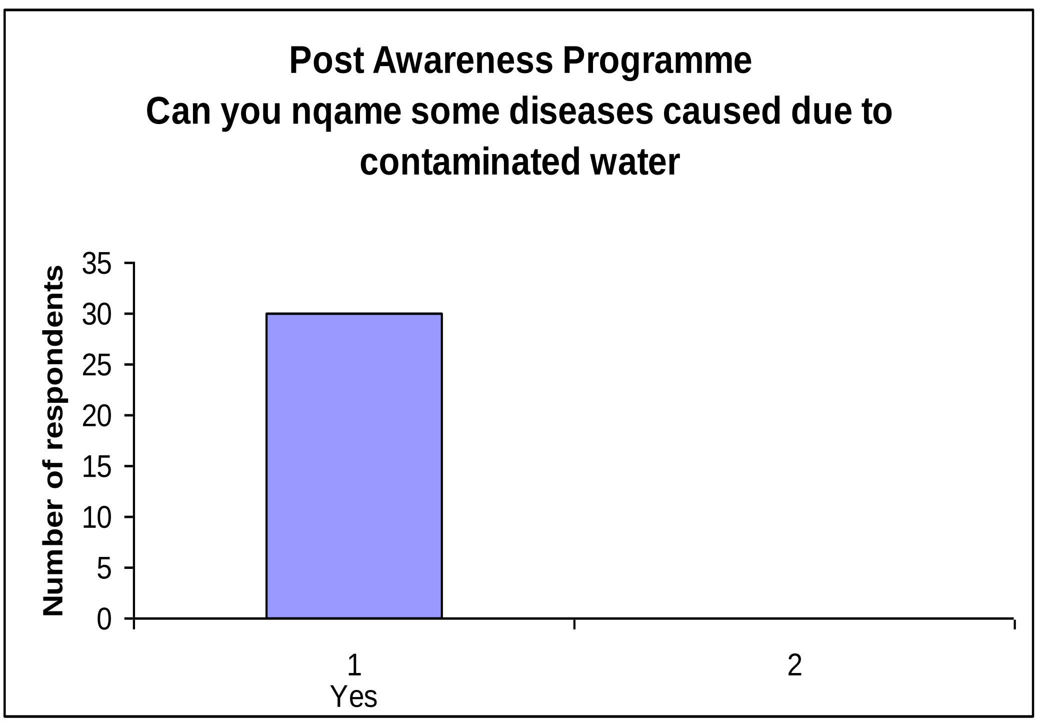


Figure 37: Pre awareness knowledge on ability to name a few water borne diseases
Out of 30 students all the 30 students said yes

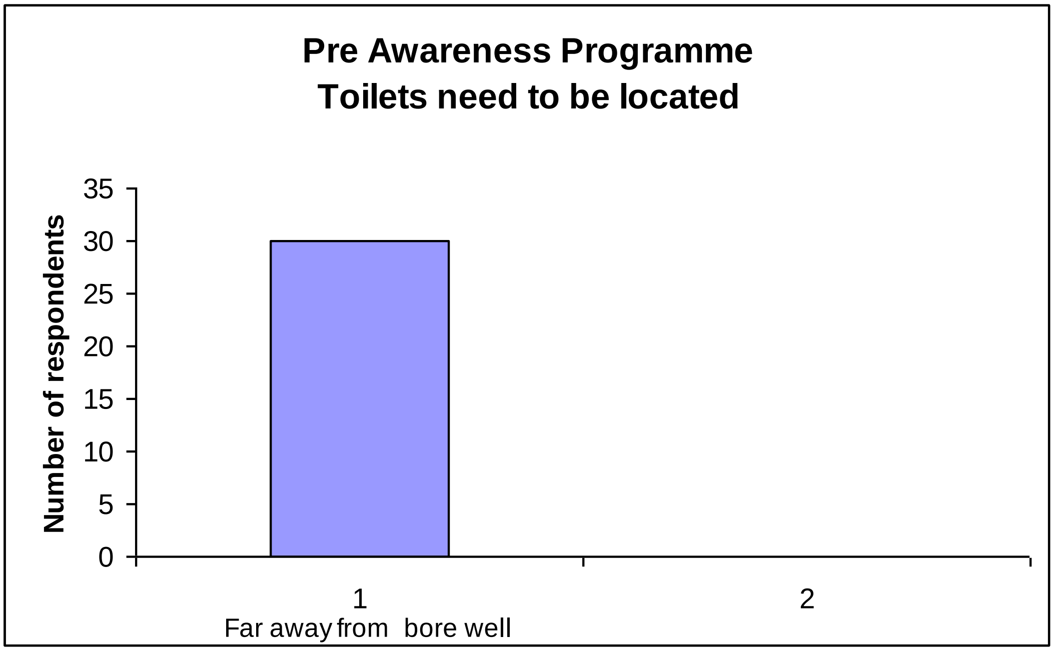


Figure 38: Pre awareness knowledge on location of toilets

Out of 30 students all the 30 students said yes

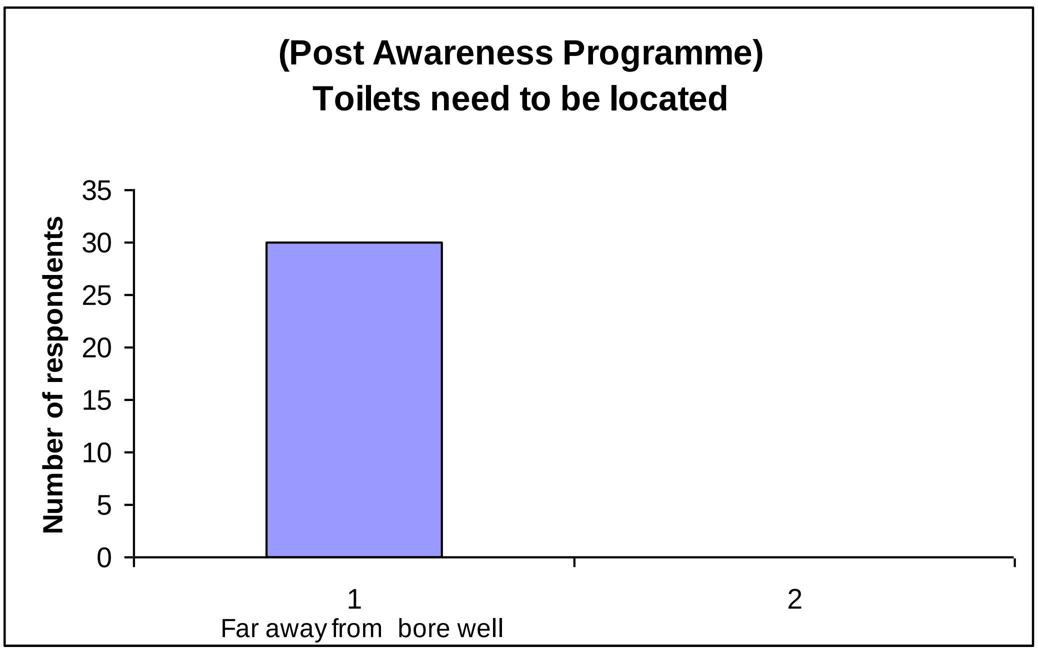


Figure 39: Post awareness knowledge on location of toilets

Out of 30 students all the 30 students said yes

Do you know what parameters are tested for checking the potability of water? Name them

None of the students could correctly name them.

Plate 38: Research Assistant doing a water analysis demonstration at Waje High School, Waje, Panvel

Plate 39: Discussion of project team with teachers at Waje high School, Waje, Panvel

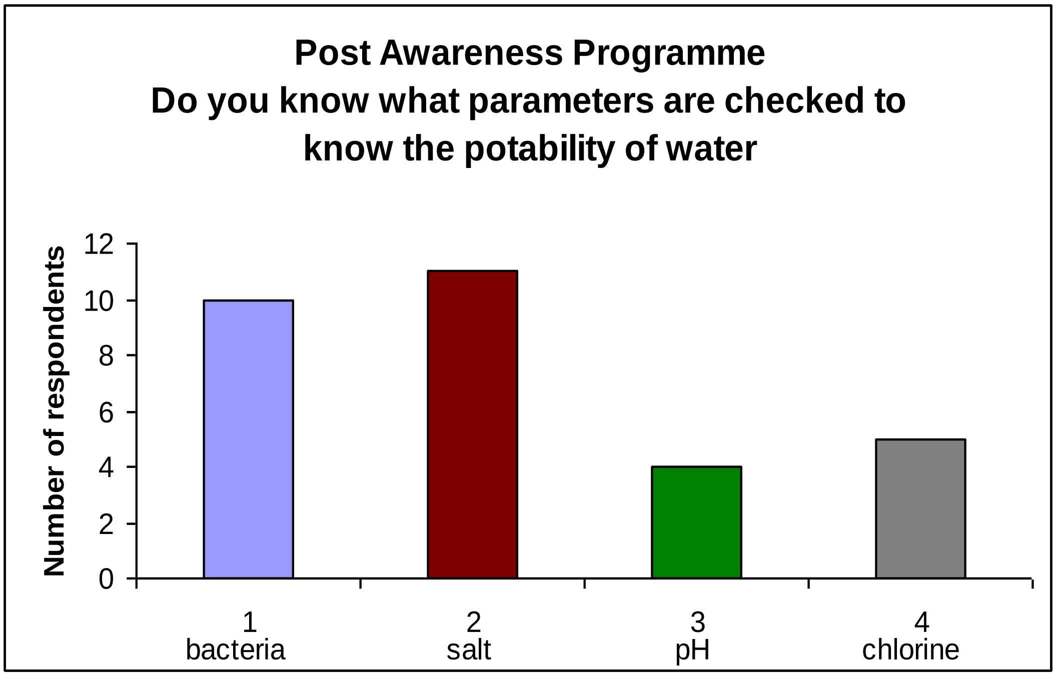


Figure 40: Post awareness knowledge on naming water quality parameters to be checked

Out of 30 students 10 said bacteria and 11 said salts and 4 said pH and 5 said chlorine

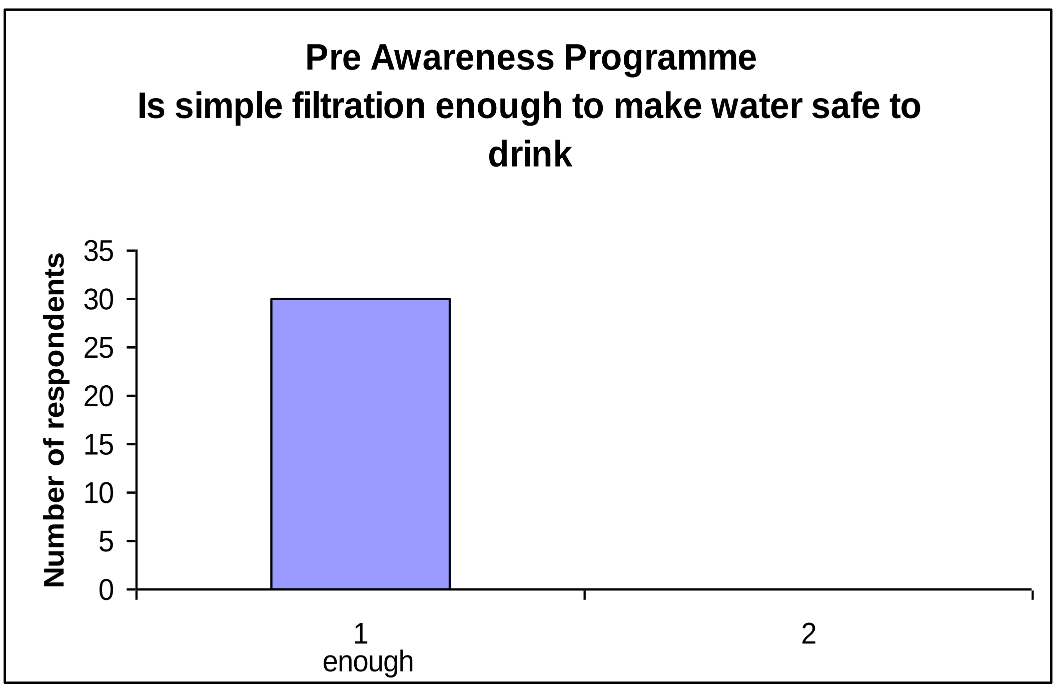


Figure 41: Pre awareness knowledge on adequacy of water filtration

Out of 30 students all said that it is enough

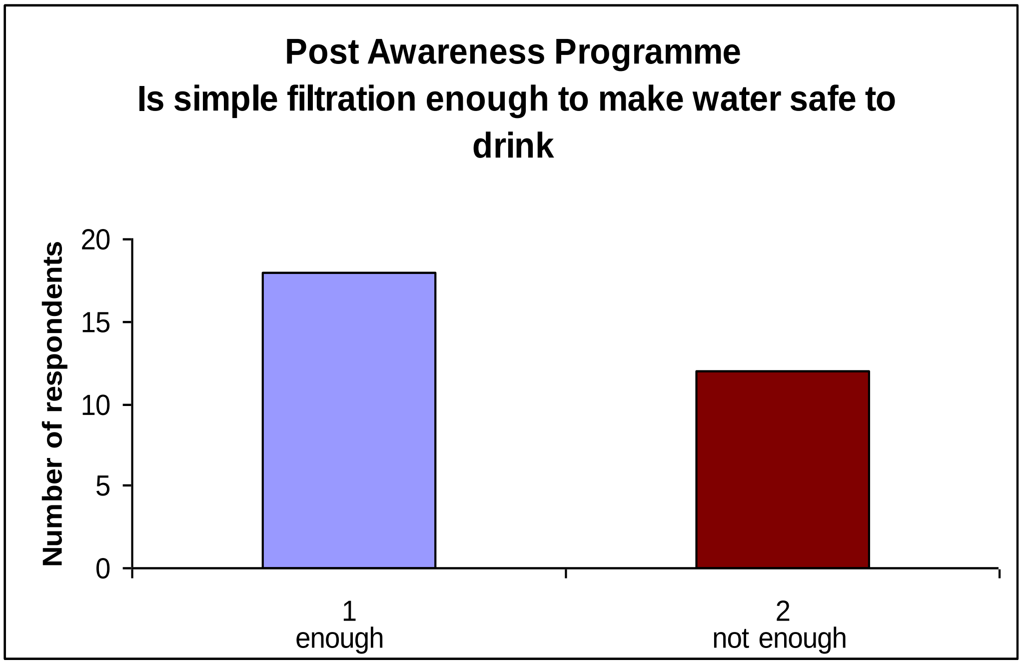


Figure 42: Post awareness knowledge on adequacy of water filtration
Out of 30 students 18 said that it is enough while 12 said that it is not enough

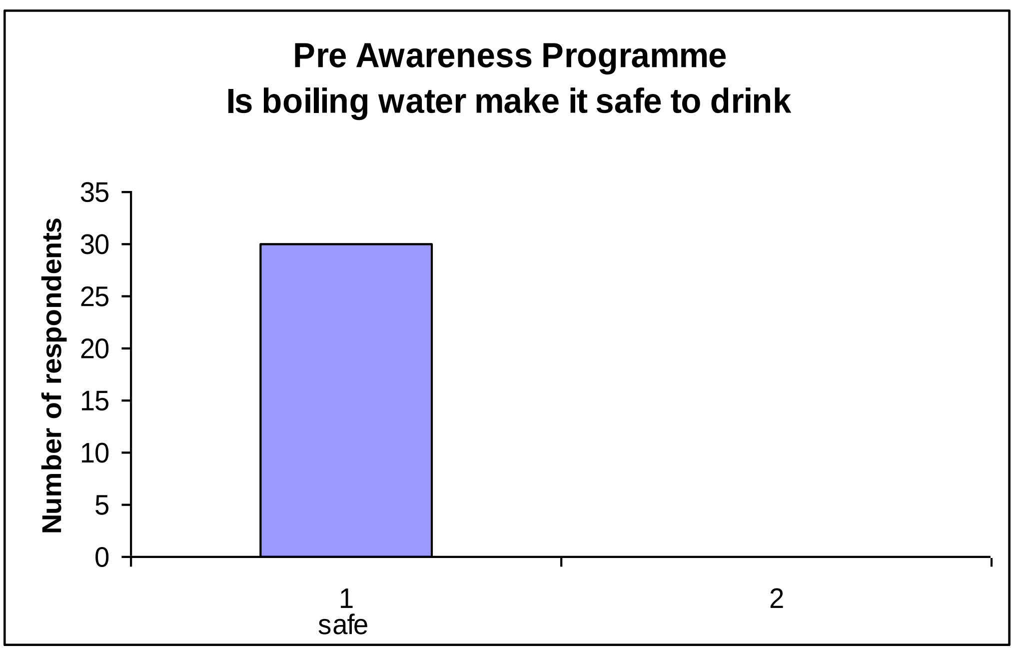


Figure 43: Pre awareness knowledge on boiling of water
Out of 30 students all said yes

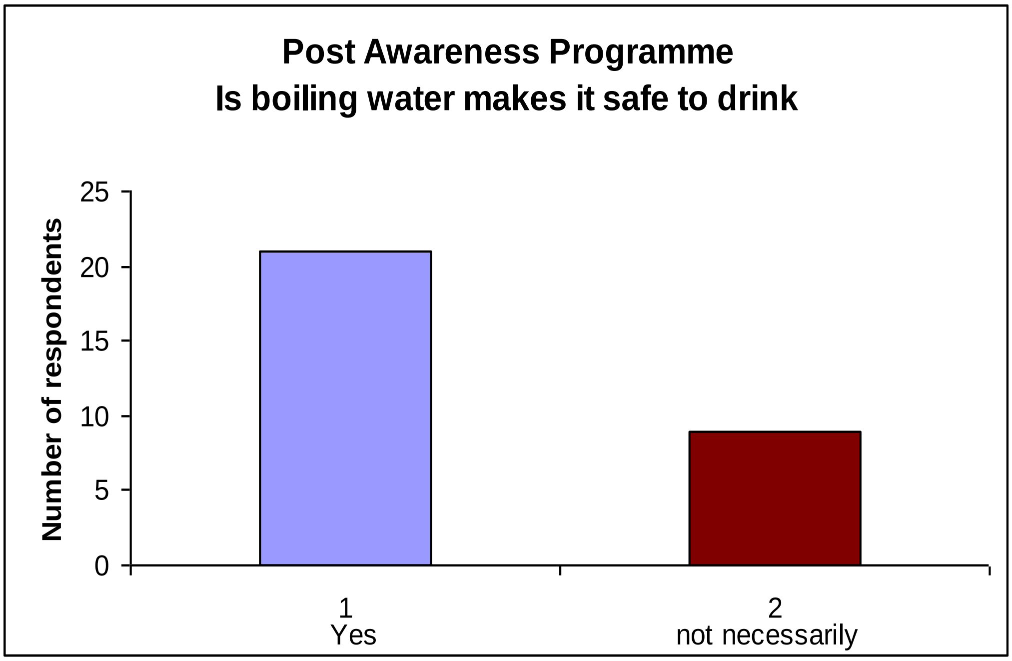


Figure 44: Post awareness knowledge on boiling of water
Out of 30 students 21 said yes and nine said not necessarily

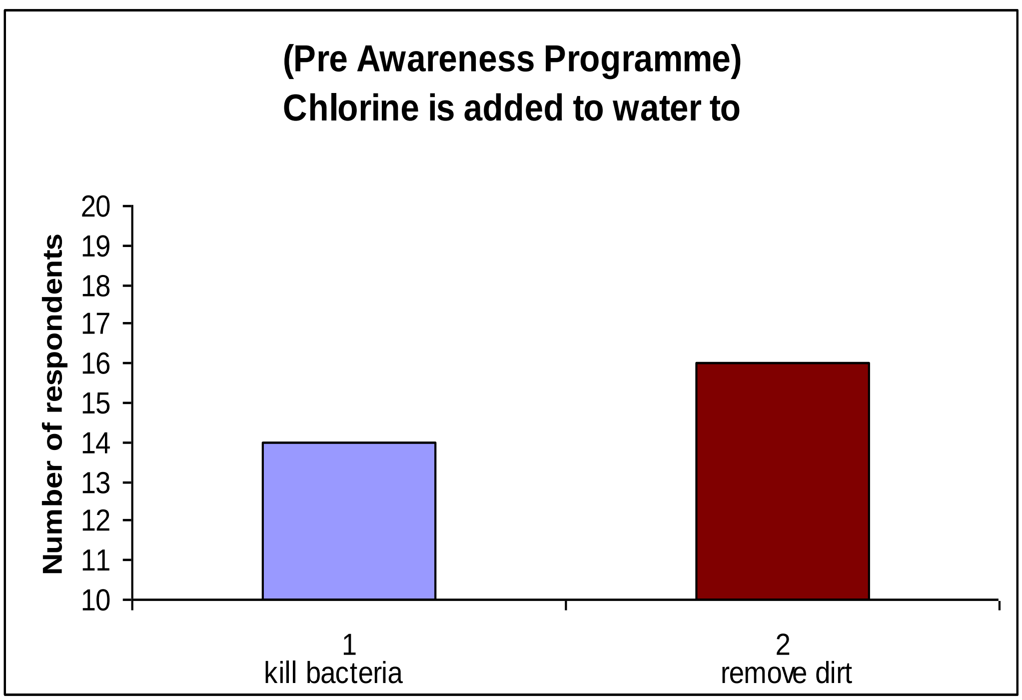


Figure 45: Pre awareness knowledge on chlorination
Out of 30 students 14 said that it is to kill bacteria and 16 said that it is to remove dirt.

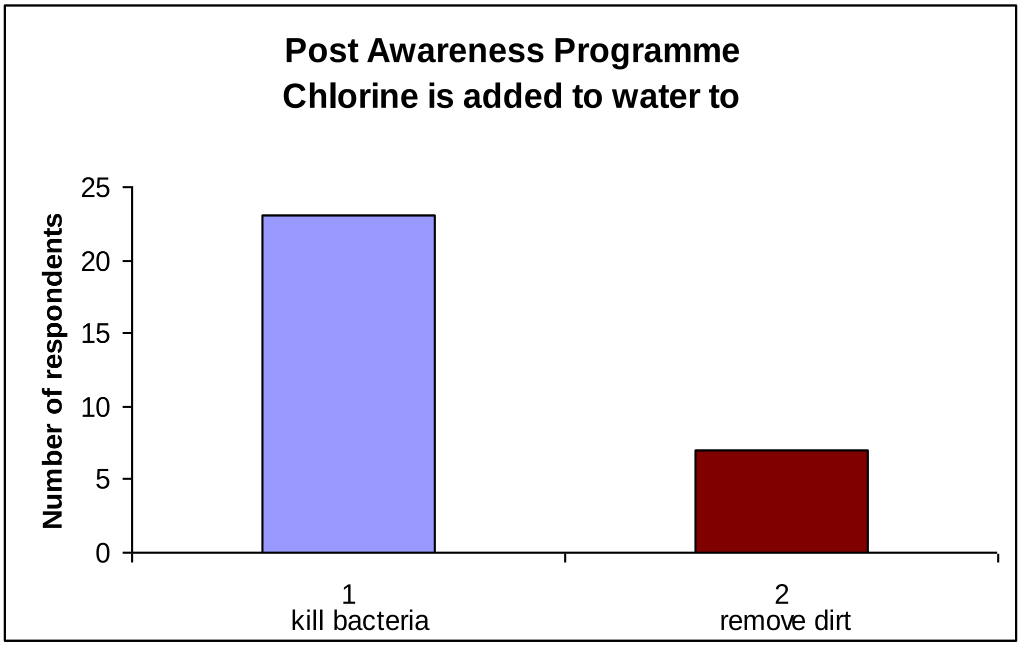


Figure 46: Post awareness knowledge on chlorination

Out of 30 students 23 said that it is to kill bacteria and 7 still said that it is to remove dirt

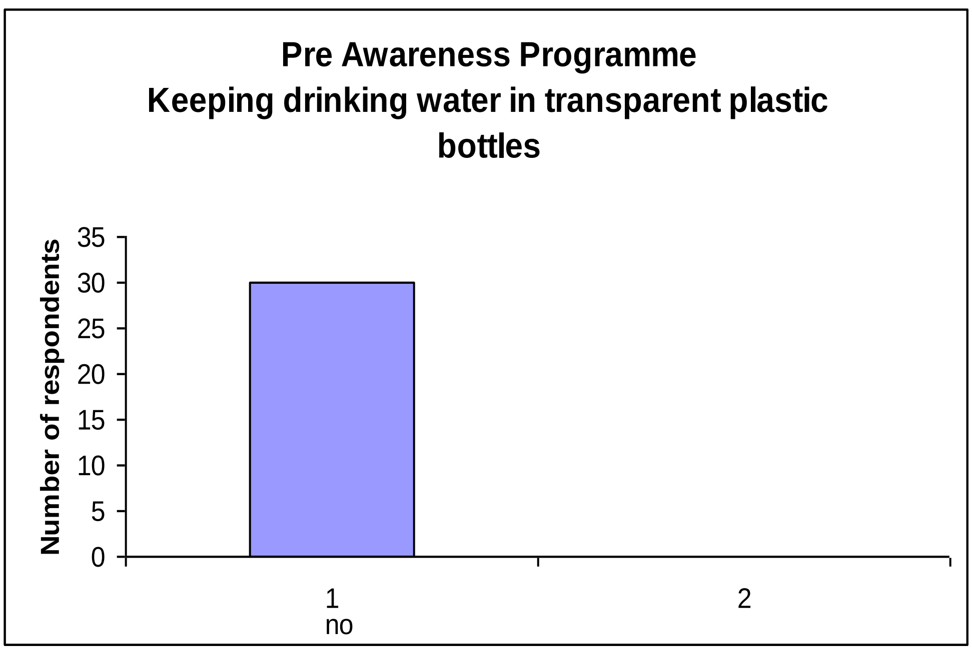


Figure 47: Pre awareness knowledge on solar disinfection

Out of 30 students all said no.

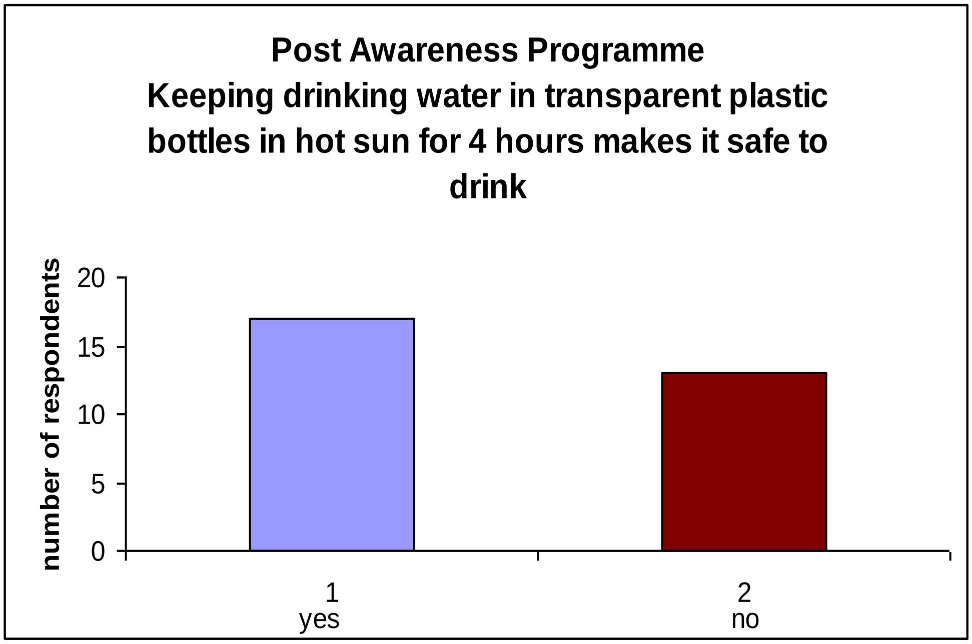


Figure 48: Post awareness knowledge on solar disinfection

Out of 30 students 17 said yes while 13 said no.

Awareness Programme No. 2

Participants: Students of class VIII and IX and teachers from Nere High School, Nere, Panvel

Total Number of students: 20

Date": 24th March 2014

Table 37: Participants' response to awareness programme- Nere High School

Question .No.	Pre- Awareness Programme response	Post-awareness programme response
1 Sea water is not potable because	Out of 20 students 3 students said it is dirty while 17 students said that it is salty.	Out of 20 students 13 students said that it is salty and 7 students said that the dissolved salts are harmful to health.
2 Could drinking water cause diseases?	Out of 20 students 17 said yes while 3 said no.	Out of 20 students 20 said yes
3 Could the quality of drinking water be ascertained by its appearance?	Out of 20 students all the 20 students said yes	Out of 20 students 17 said yes while 3 said no.
4 Could the quality of drinking water ascertained by its taste?	Out of 20 students all the 20 students said yes	Out of 20 students 16 said yes while 4 said no.

5 The same water could be used for drinking, cooking and washing?	Out of 20 students all the 20 students said yes	Out of 20 students 12 said yes while 6 said need not be and 2 said no.
6 Can you name some diseases caused due to contaminated water? If yes name them	Out of 20 students all the 20 students said yes Cholera, typhoid, skin disease and Jaundice were mentioned.	Out of 20 students all the 20 students said yes Cholera, typhoid, skin disease and Jaundice were mentioned
7 Toilet can be located	Out of 20 students all the 20 students said that it needs to be located far away from drinking water bore well.	Out of 20 students all the 20 students said that it needs to be located far away from drinking water bore well.
8 Do you know what parameters are tested for checking the potability of water? Name them	None of the students could correctly name them.	Out of 20 students 11 said bacteria and 7 said salts and 1 said pH and 1 said chlorine
9 Is simple filtration enough to make water safe to drink?	Out of 20 students 20 all said that it is enough	Out of 20 students 16 said that it is enough while 4 said that it is not enough
10 Is boiling water make it safe to drink?	Out of 20 students all 20 said yes.	Out of 20 students 11 said yes and 9 said not necessarily.
11 Chlorine is added to drinking water to	Out of 20 students 14 said that it is to kill bacteria and 6 said that it is to remove dirt.	Out of 20 students 17 said that it is to kill bacteria and 3 still said that it is to remove dirt.
12 Keeping drinking in transparent plastic bottles in hot sun for four hours makes it safer to drink	Out of 20 students all 20 aid no.	Out of 20 students 14 said yes while 6 said no.

Plate 40: Project staff briefing the students about the awareness generation programme at Nere High School, Nere, Panvel on 24th March 2014

Plate 41: Students filling up pre knowledge questionnaire during our Drinking Water Awareness campaign on 24th March 2014 at Nere High School, Nere, Panvel

Plate 42: Project team explaining to students at Nere High School, Nere, Panvel

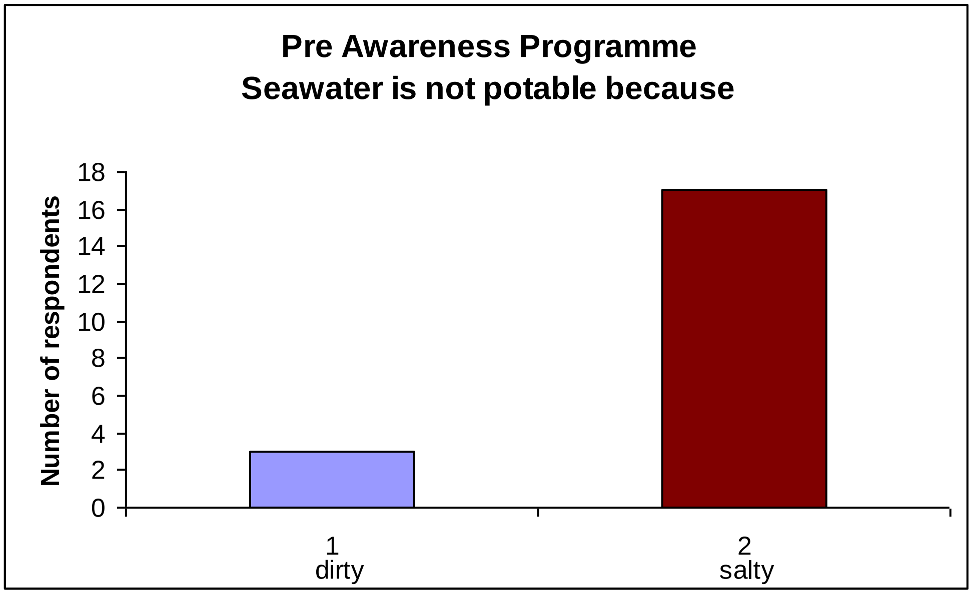


Figure 49: Pre awareness knowledge on potability of seawater
Out of 20 students 3 students said it is dirty while 17 students said that it is salty.

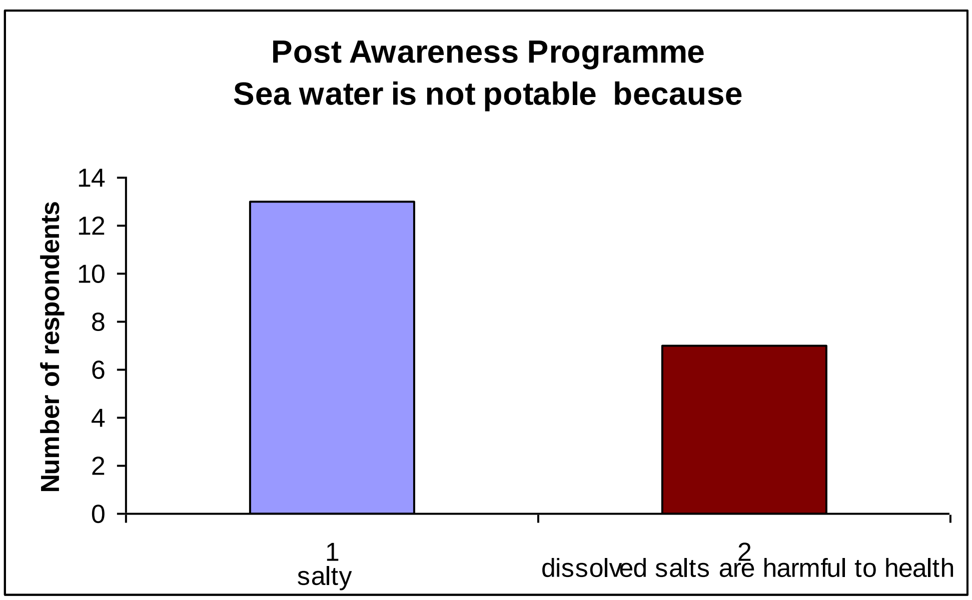


Figure 50: Post awareness knowledge on potability of seawater
Out of 20 students 13 students said that it is salty and 7 students said that the dissolved salts are harmful to health.

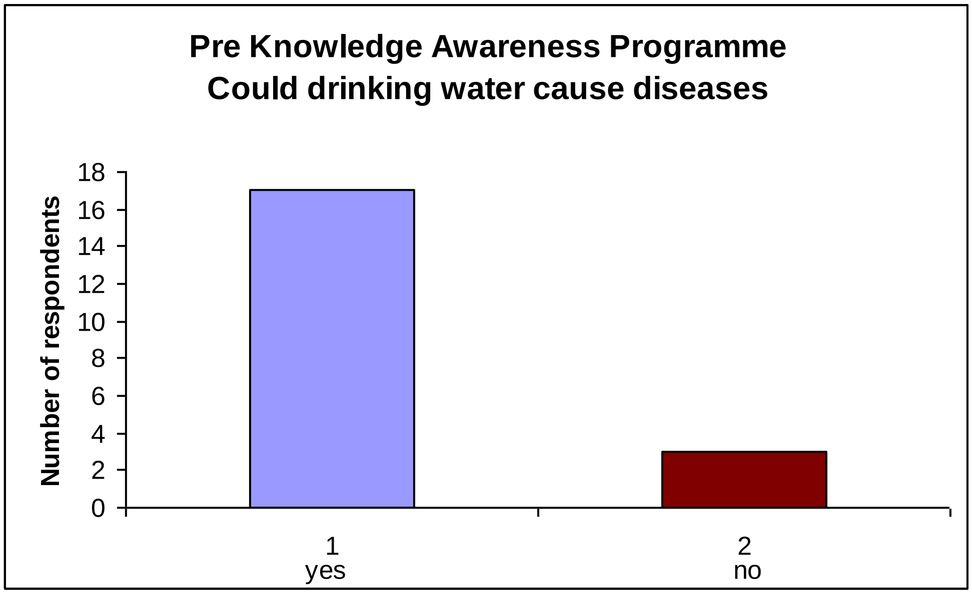


Figure 51: Pre awareness knowledge on drinking water and diseases
Out of 20 students 17 said yes while 3 said no.

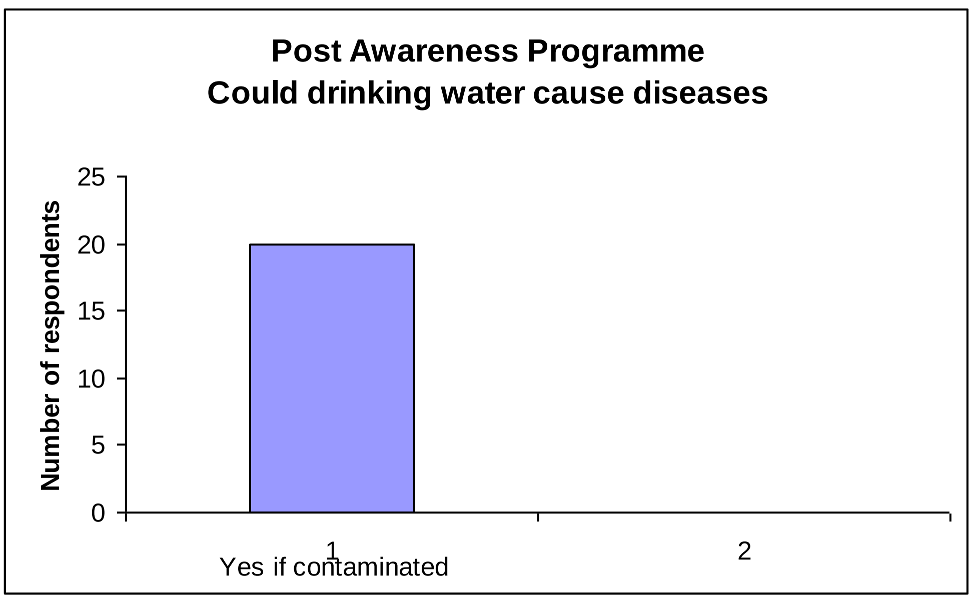


Figure 52: Post awareness knowledge on drinking water and diseases
Out of 20 students 20 said yes

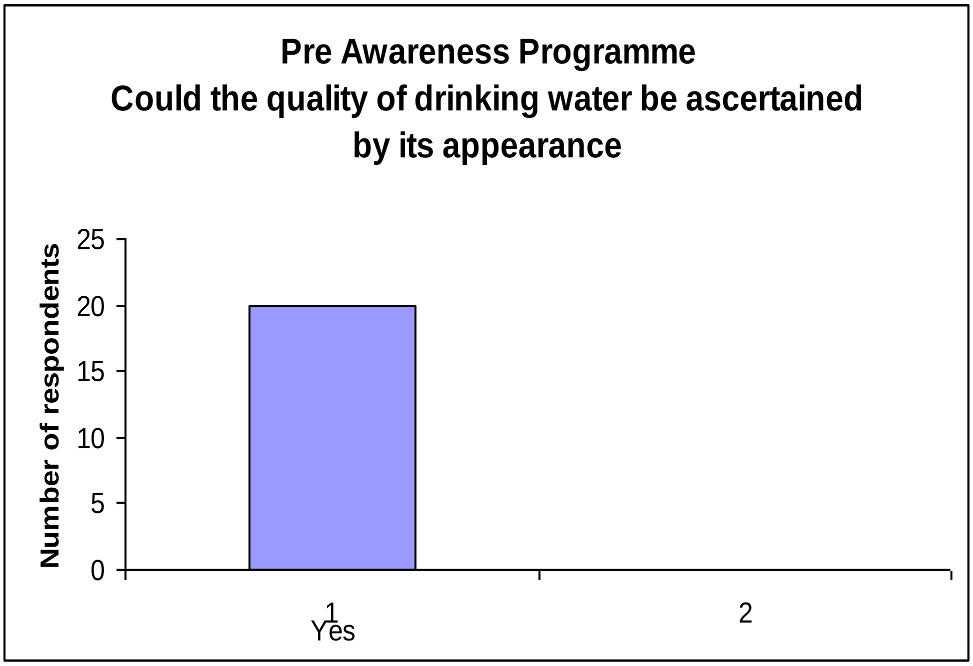


Figure 53: Pre awareness knowledge on quality of drinking water and its appearance

Out of 20 students all the 20 students said yes

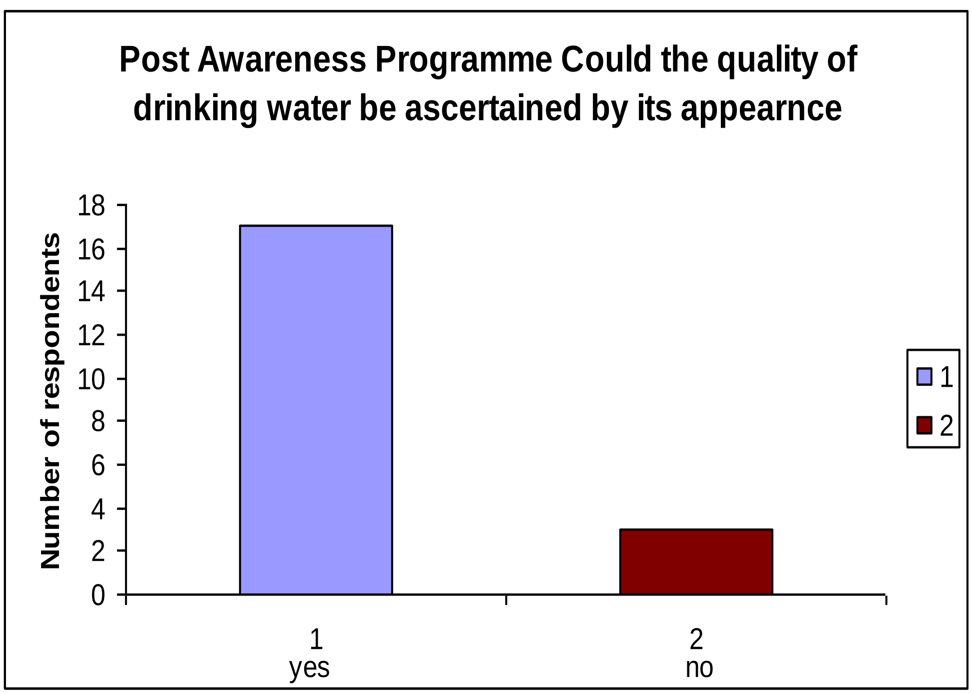


Figure 54: Post awareness knowledge on quality of drinking water and its appearance

Out of 20 students 17 said yes while 3 said no.

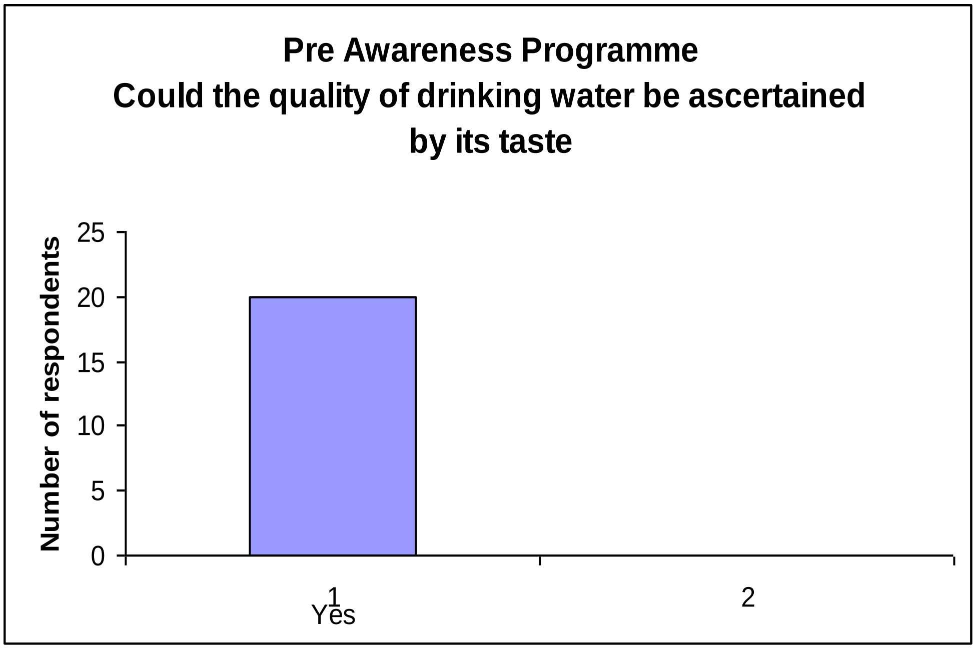


Figure 55: Pre awareness knowledge on quality of drinking water and its taste
Out of 20 students all the 20 students said yes

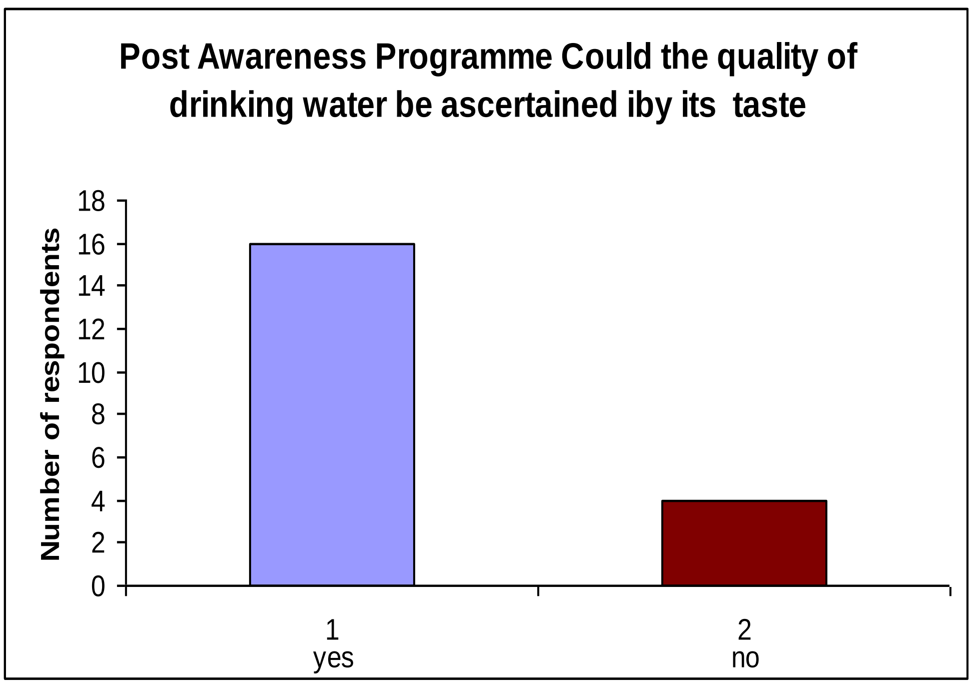


Figure 56: Post awareness knowledge on quality of drinking water and its taste
Out of 20 students 16 said yes while 4 said no.

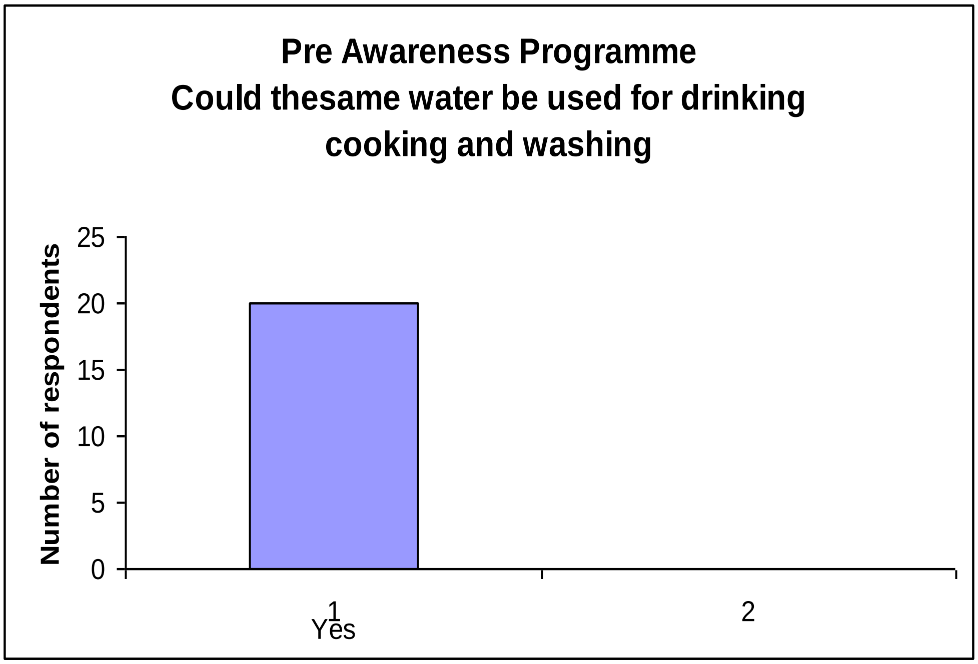


Figure 57: Pre awareness knowledge on using drinking water for cooking and washing

Out of 20 students all the 20 students said yes

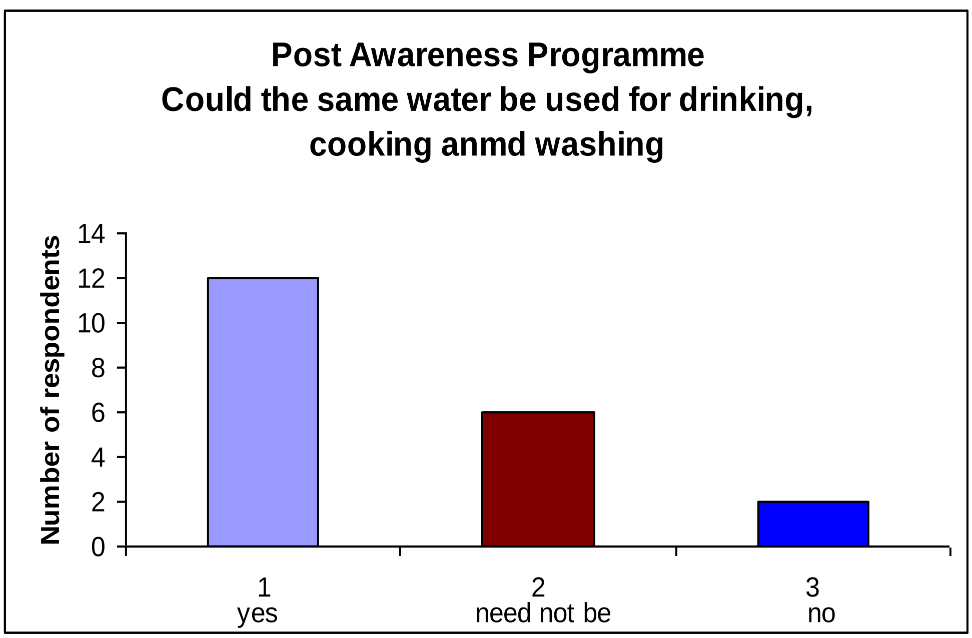


Figure 58: Post awareness knowledge on using drinking water for cooking and washing

Out of 20 students 12 said yes while 6 said need not be and 2 said no.

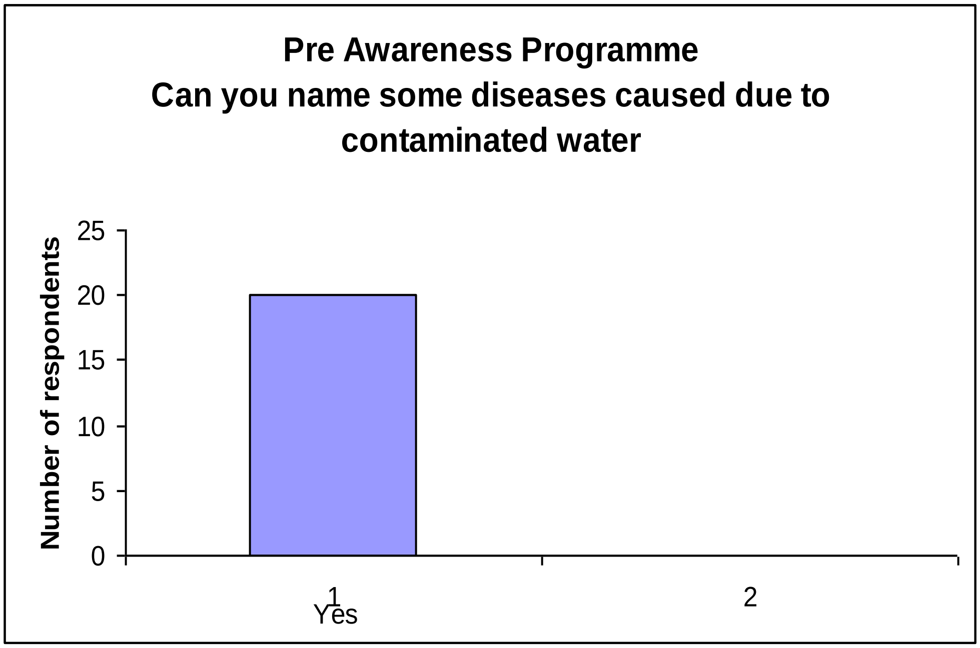


Figure 59: Pre awareness knowledge on ability to name water borne diseases

Out of 20 students all the 20 students said yes

Cholera, typhoid, skin disease and Jaundice were mentioned.

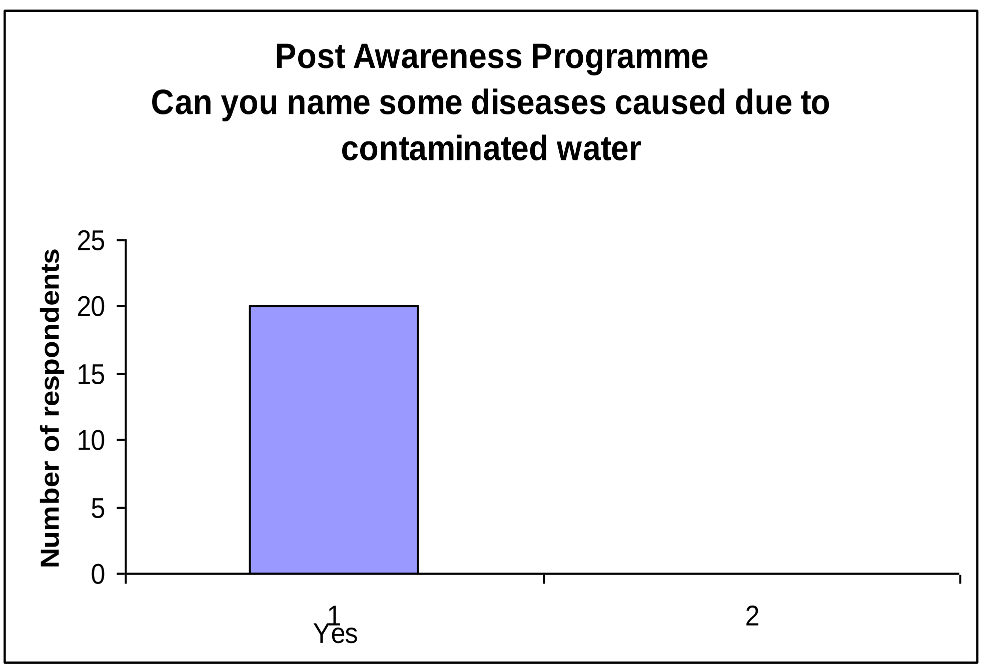


Figure 60: Pre awareness knowledge on ability to name water borne diseases

Out of 20 students all the 20 students said yes

Cholera, typhoid, skin disease and Jaundice were mentioned

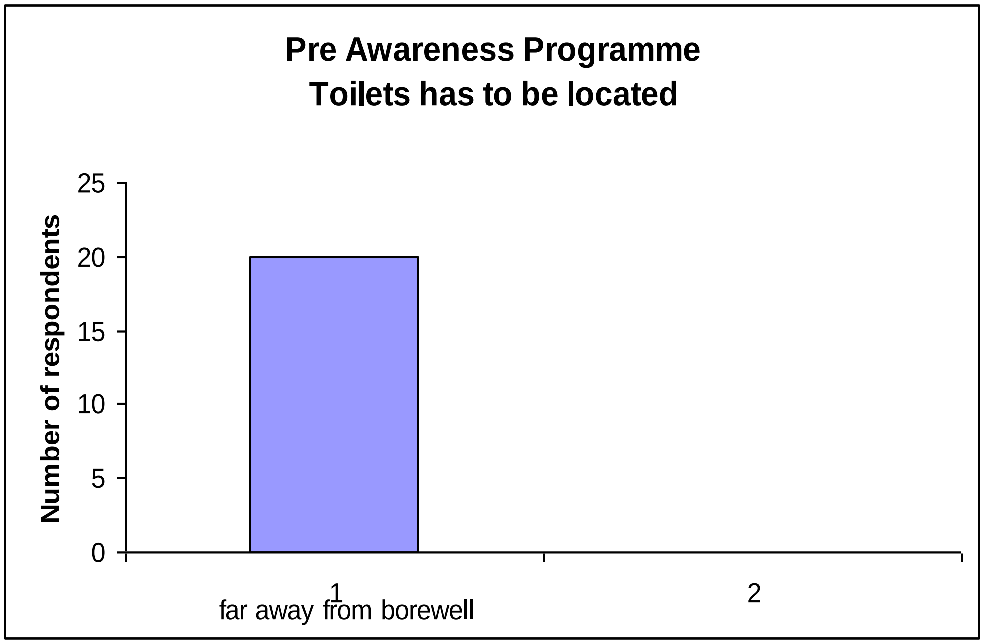


Figure 61: Pre awareness programme on location of toilets

Out of 20 students all the 20 students said that it needs to be located far away from drinking water bore well.

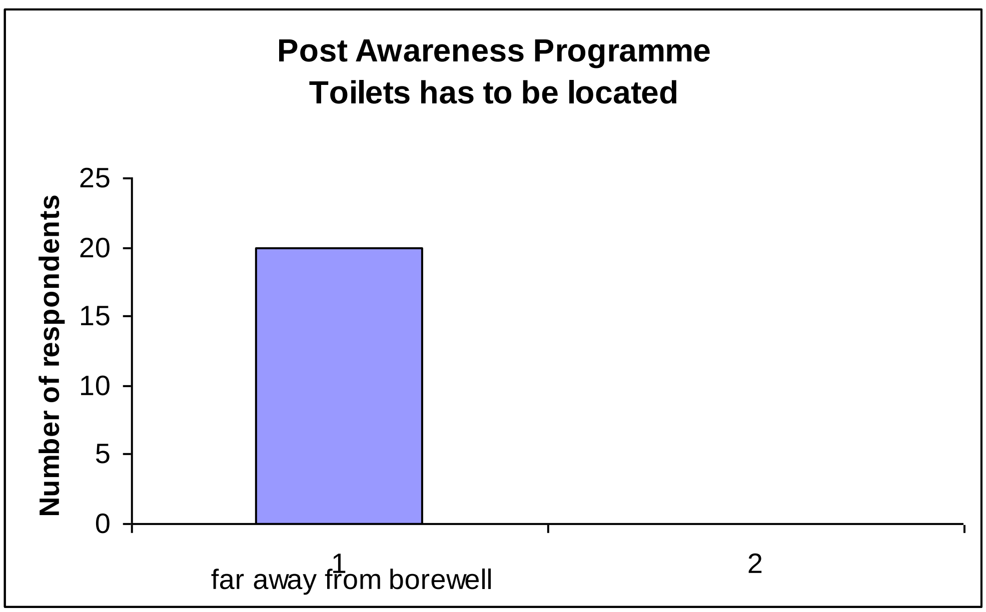


Figure 62: Post awareness knowledge on location of toilets

Out of 20 students all the 20 students said that it needs to be located far away from drinking water bore well.

When asked what parameters are tested for checking the potability of water, none of the students could correctly name them.

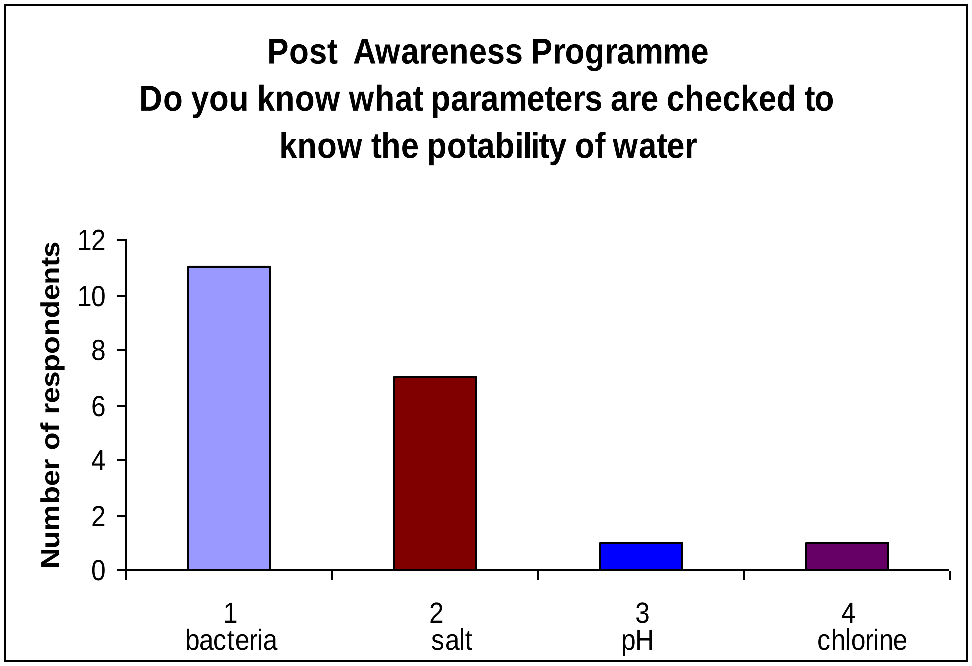


Figure 63: Post awareness knowledge on water quality parameters
Out of 20 students 11 said bacteria and 7 said salts and 1 said pH and 1 said chlorine

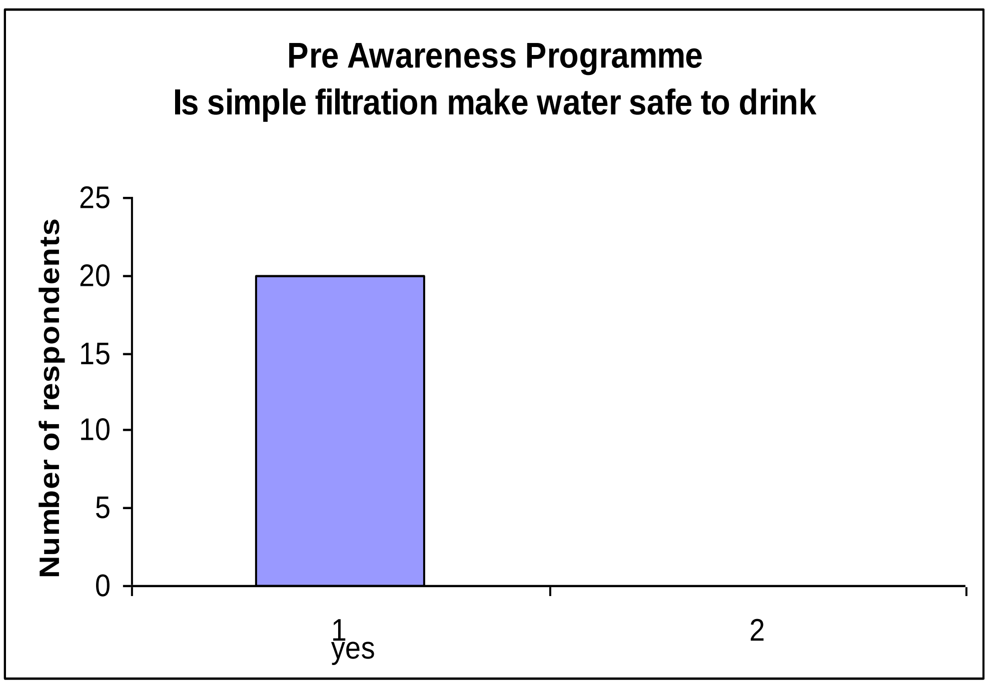


Figure 64: Pre awareness knowledge on usefulness of water filtration
Out of 20 students 20 all said that it is enough

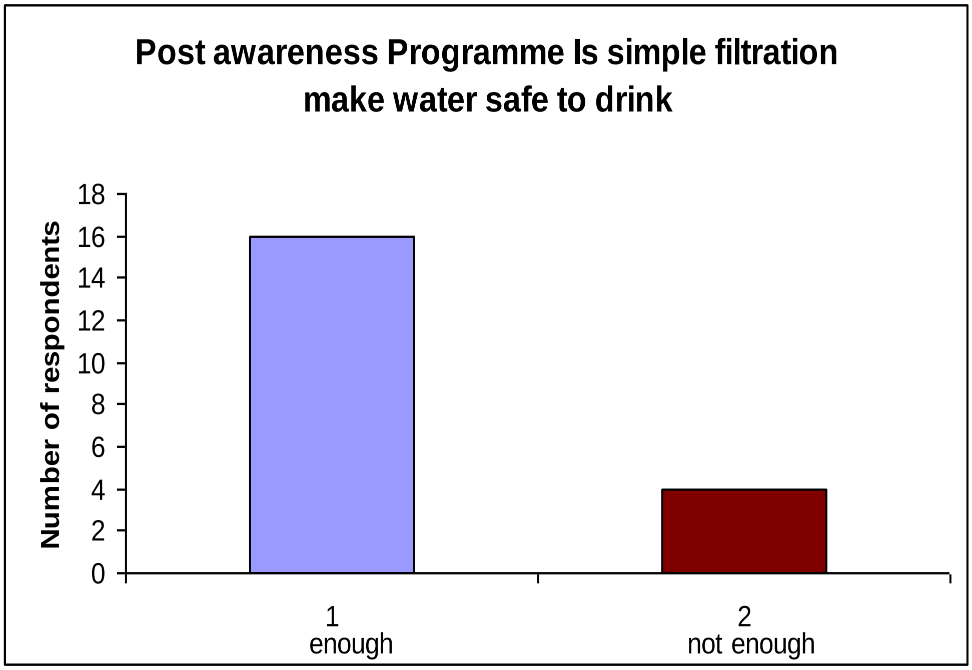


Figure 65: Post awareness knowledge on usefulness of water filtration
Out of 20 students 16 said that it is enough while 4 said that it is not enough

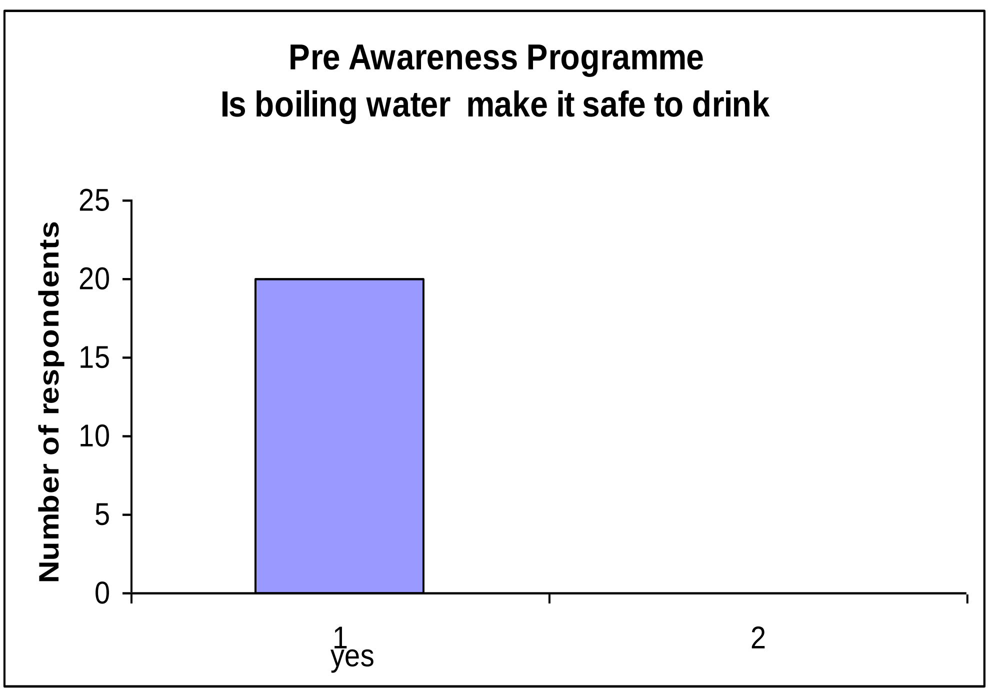


Figure 66: Pre awareness programme on need for boiling water
Out of 20 students all 20 said yes.

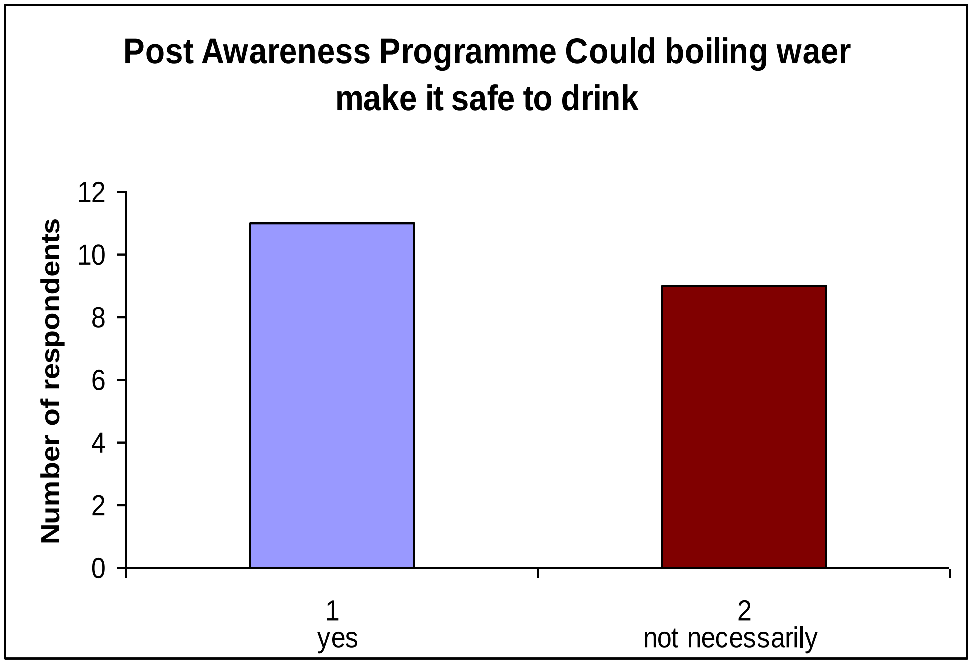


Figure 67: Post awareness knowledge on need for boiling water
Out of 20 students 11 said yes and 9 said not necessarily.

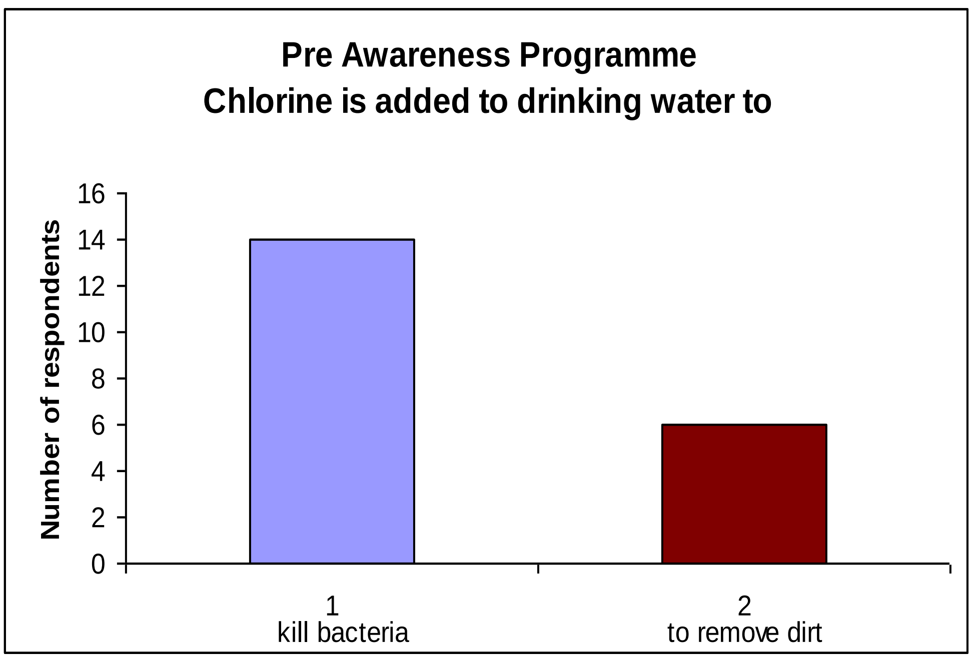


Figure 68: Pre awareness knowledge on need for chlorination
Out of 20 students 14 said that it is to kill bacteria and 6 said that it is to remove dirt.

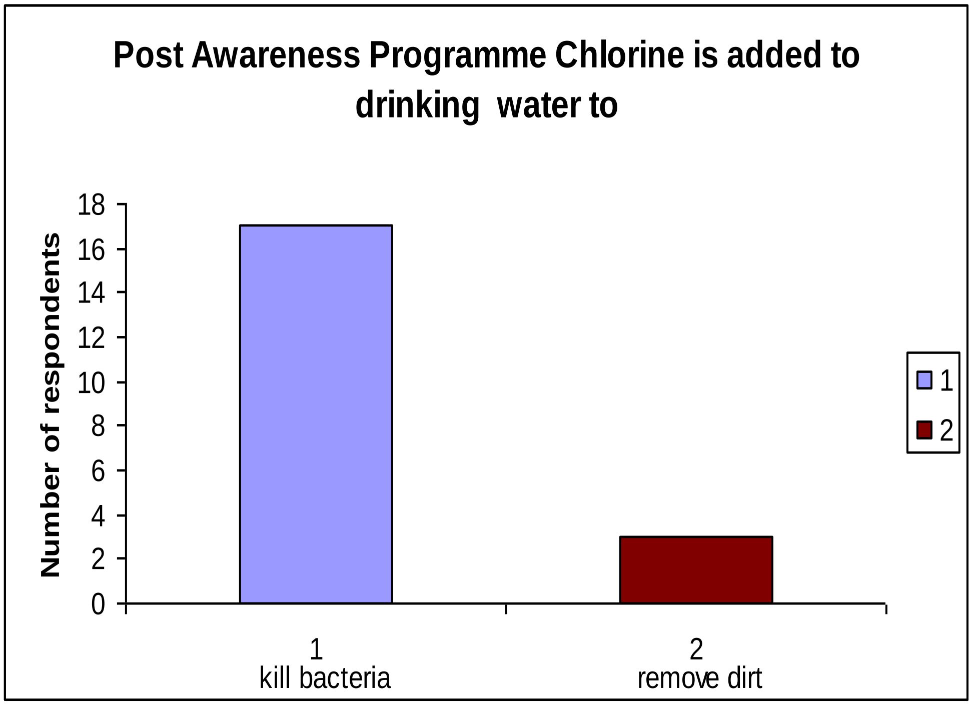


Figure 69: Post awareness knowledge on need for chlorination

Out of 20 students 17 said that it is to kill bacteria and 3 still said that it is to remove dirt.

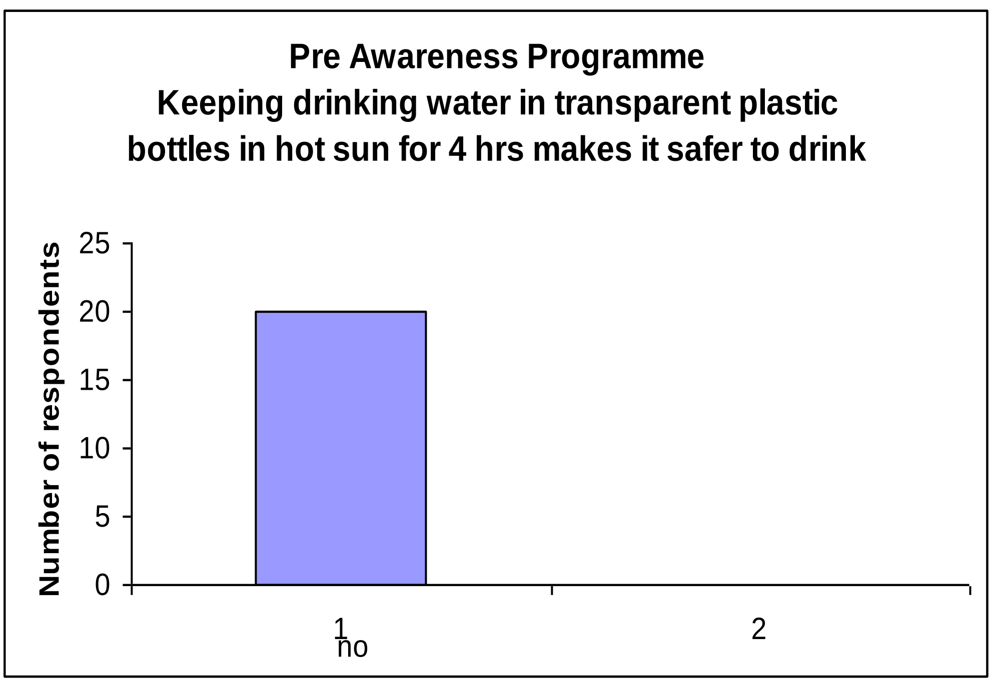


Figure 70: Pre awareness knowledge on solar disinfection

Out of 20 students all 20 aid no.

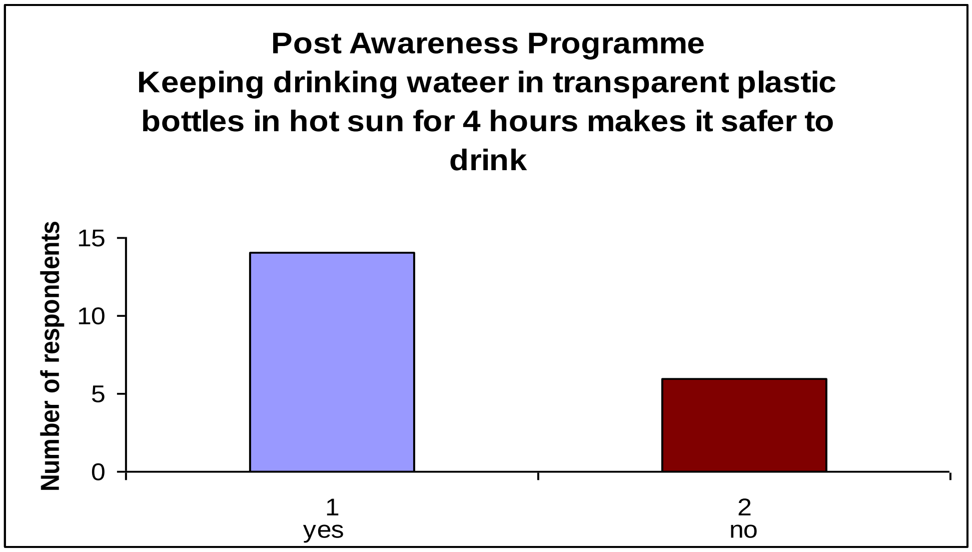


Figure 71: Post awareness knowledge on solar disinfection

Out of 20 students 14 said yes while 6 said no.

Plate 43: On the spot demonstration of testing of bore well water to teaching staff at Nere High School, Nere, Panvel

Awareness Programme No. 3

Third awareness generation programme was conducted on 12th July 2014 at Shri. Annabhau Sahastrabudhhe Anudanit Adivasi Asharamshala, Wakdi, Panvel, Raigad (M. S.). The main objective of awareness programme was to sensitize students about the drinking water sources, contamination of drinking water and low cost household disinfection techniques. The target students were selected from 8th to 10th standard. The knowledge of students was assessed before and after the training programme in order to know the impact of training on students.

Total 100 students were selected for training programme. Out of total 100 respondents 62 questionnaires were selected for analysis because they were completely filled for pre and post knowledge survey as well as all the questions was answered. A positive and significant correlation was not observed in between independent variables (age, sex, education and family size) and knowledge about the water contamination and disinfection technologies at 95% confidence interval of correlation coefficient before training (Table- 38). This depicted that respondents were not aware about the problems associated with water contamination and techniques for purification. This confirms that training on water contamination and purification techniques would help in the improvement of knowledge of selected respondents.

Table 38: Correlation between independent variable and knowledge level of respondents

Sr. No.	Dependent variables	Independent variables			
		Age	Sex	Family size	Education
1.	Contaminated drinking water causes diseases	0.139	0.281	0.137	0.202
2.	Name of diseases caused by drinking water	-0.022	0.103	-0.117	0.229
3.	Contaminated drinking water can be identified from appearance	-0.169	-0.229	0.048	-0.238
4.	Contaminated drinking water can be identified from taste	-0.16	0.129	0.134	-0.007
5.	Contaminated drinking water can be identified from odour	-0.045	-0.104	-0.126	0.088
6.	Filtration technique for the purification of drinking water	-0.092	-0.035	0.066	-0.069
7.	Boiling technique for the purification of drinking water	-0.032	-0.073	-0.176	-0.008
8.	Chlorination technique for the purification of drinking water	0.105	-0.145	-0.122	-0.005
9.	SODIS technique for the purification of drinking water	0.125	0.048	0.031	0.262

Improvement in knowledge level was observed with the training programme (Figures 72-77; Table 39). Initially 17 participants were aware and 45 unaware about the identification of water contamination by observing it. After training 60 participants were aware and 2 participants were unaware about it (Figure 72).

Before training 33 participants were aware and 29 unaware about the change in taste of drinking water due to contamination. However, after training 40 respondents were aware and 22 unaware about it (Figure 73).

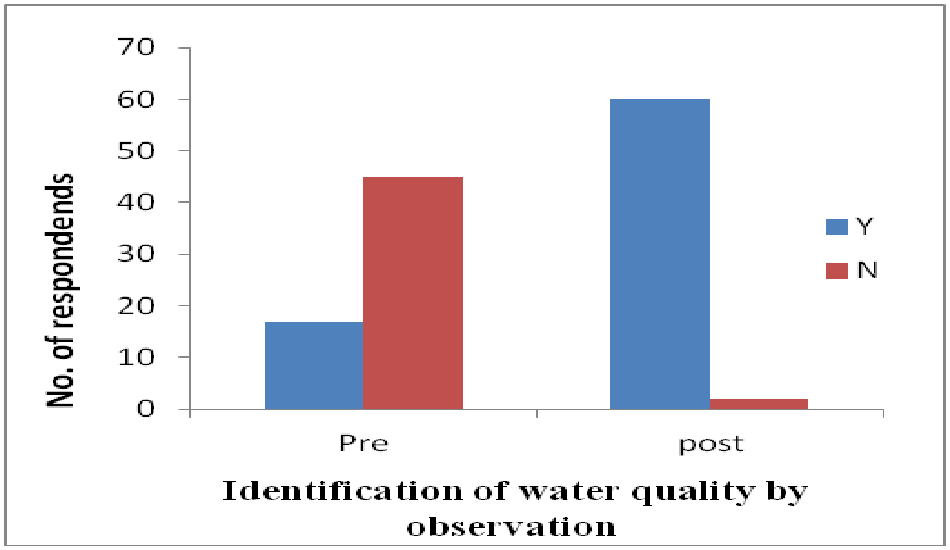


Figure 72: Pre and post training knowledge of respondents about appearance of contaminated drinking water

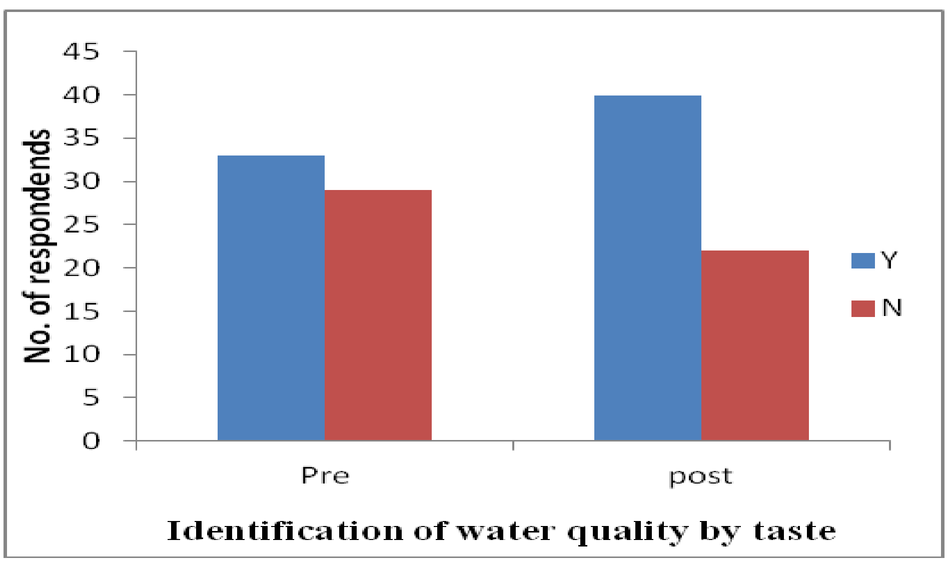


Figure 73: Pre and post training knowledge of respondents about the taste of contaminated drinking water

It is apparent from Figure 74 that out of 62 respondents 32 were aware and 30 unaware about the filtration process for the purification of contaminated water. After training 40 respondents were aware and 22 were unaware.

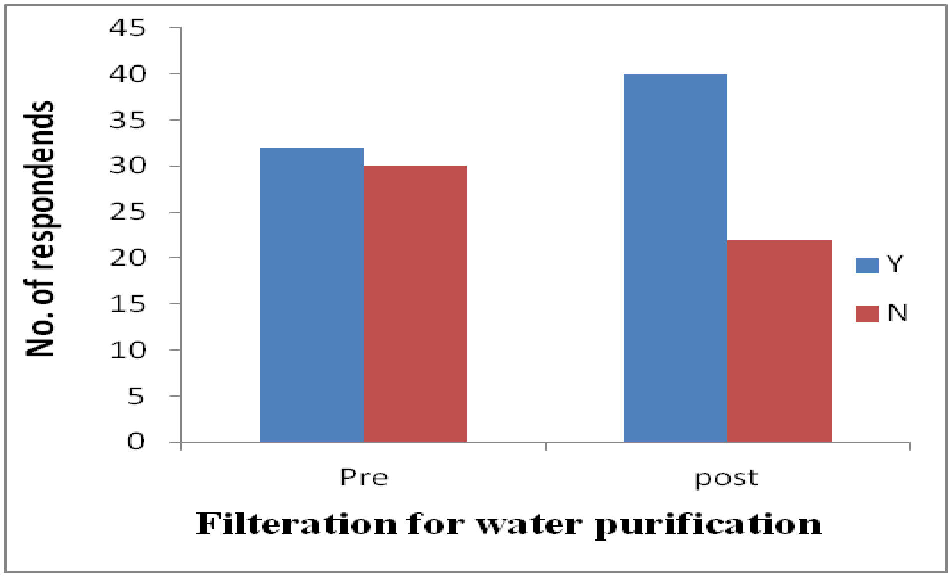


Figure 74: Pre and post training knowledge of respondents about purification of contaminated drinking water by filtration

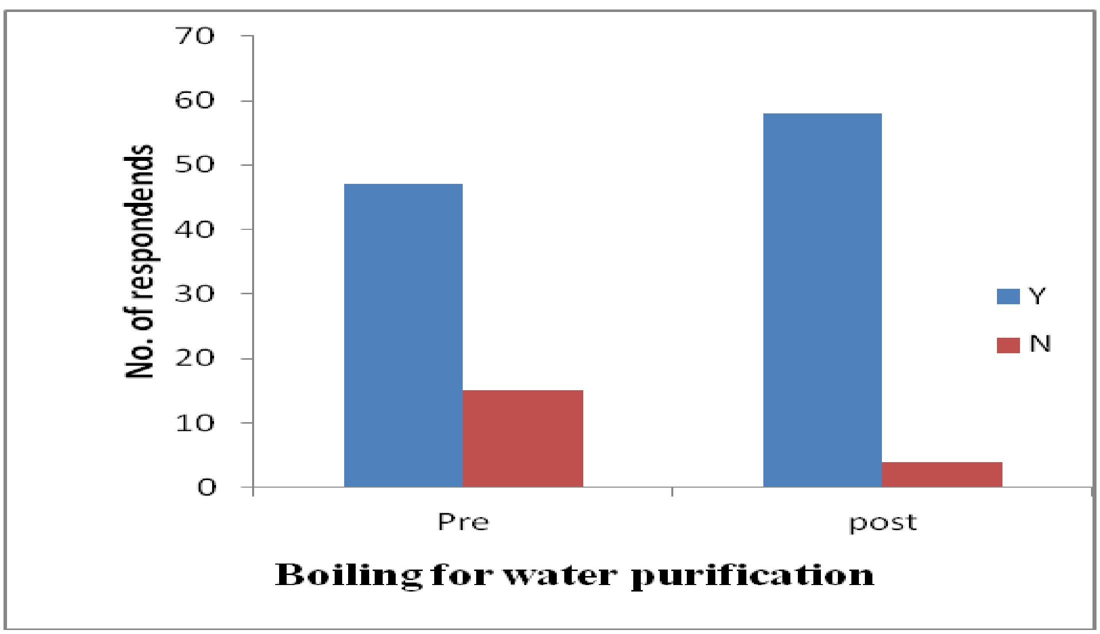


Figure 75: Pre and post training knowledge of respondents about purification of contaminated drinking water by boiling

Plate 44: Students completing their identity particulars in the form at Annabhau Sahasrabudhe Anudanit Ashramshala, Wakadi, Panvel on 12th July 2014

Plate 45: Project Team briefing the students about the Programme

About water boiling process for the disinfection of contaminated water 47 respondents were aware and 15 were unaware before training (Figure 75). After training 58 students were aware and 4 students were unaware.

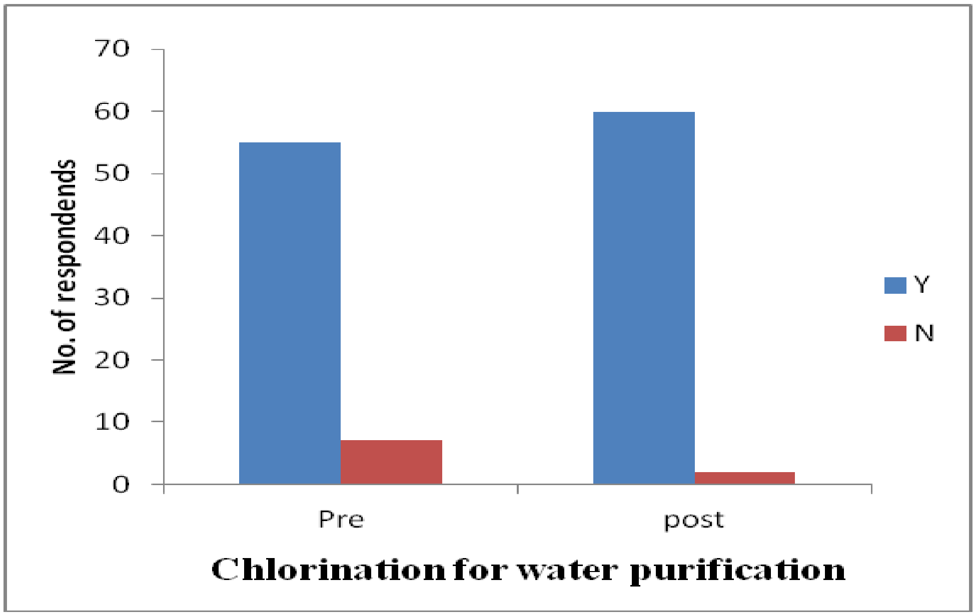


Figure 76: Pre and post training knowledge of respondents about purification of contaminated drinking water by chlorination

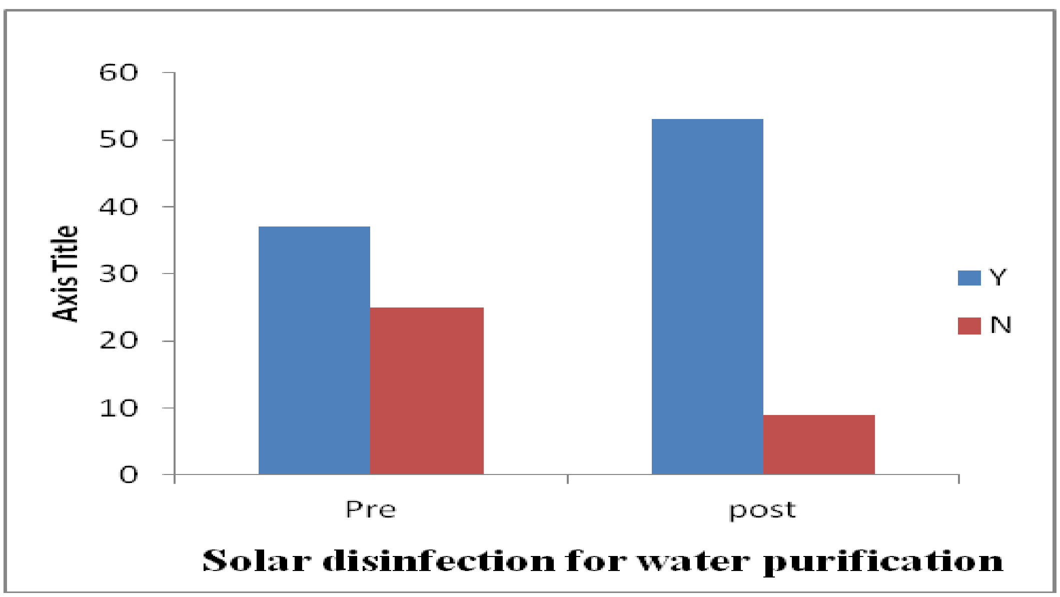


Figure 77: Pre and post training knowledge of respondents about purification of contaminated drinking water by solar disinfection

Plate 46: Project team member getting a feedback from students

Plate 47: Project staff briefing students about water disinfection

Plate 48: Students reading posters during training progrrame

Plate 49: Project Team Member giving presentation on sources of water pollution and diseases from contaminated water to students

Maximum students were aware 47 and 58 about chlorination process for water disinfection before and after training, respectively (Figure 76). However, 7 and 2 respondents were unaware about chlorination before and after training, respectively.
About solar disinfection technique 37 respondents were aware and 25 were unaware before training programme (Figure 77). After training 53 respondents were aware and 9 respondents were unaware.

Table 39: Pre and post knowledge level of respondents before and after trainings on selected areas

Sr. no.	Variables	Mean Score of Pre Test	Mean Score of Post Test	't' value
1.	Contaminated drinking water causes diseases	1.19	1.26	1.99*
2.	Name of diseases caused by drinking water	3.0	3.37	1.99*
3.	Contaminated drinking water can be identified from appearance	1.72	1.97	1.99*
4.	Contaminated drinking water can be identified from taste	1.35	1.47	1.99*
5.	Contaminated drinking water can be identified from odour	1.65	1.72	2.00*
6.	Filtration technique for the purification of drinking water	1.35	1.48	1.99*
7.	Boiling technique for the purification of drinking water	1.06	1.24	1.99*
8.	Chlorination technique for the purification of drinking water	1.03	1.11	1.99*
9.	SODIS technique for the purification of drinking water	1.15	1.60	1.99*

*Significant at $P< 0.10$ level (2- tailed)

It is apparent from table 39 that knowledge level of respondents was significantly improved ($p<0.10$) with the training programme. Thus, training programme had positively improved the knowledge level of respondents.

Awareness Programme No. 4

Fourth awareness generation programme under MMR- EIS sponsored project was conducted on 12th September 2014 at Shri. Balwantrai Mehta Panchayatiraj Jagruti Kendra, Shantivan, Panvel, Raigad (M. S.). The main aim of the training programme was to impart general and technical knowledge about the quality of clean drinking water, problems associated with contaminated water and low cost methods for purification among students from 3 selected schools, villagers from selected villages and stakeholders from local NGOs. The programme was started at 10.30 am and ended at 1.00 pm. Total 98 participants registered in the programme. The details are as given below.

Table 40: Details of Participants in training programme

Sr.No.	Participants	Name of School/ Village	No. of participants
1.	Students and teachers	Sri. Annabhau Shastrabudhe Anudanit Ashramshala, Shantivan, Wakadi (Panvel)	22
		Waje High School,Waze	16
		Kewale High School, Kewale	10
2.	Villagers	Vangani Usarli Shivkar Wajapur Nere	6 2 2 4 3
3.	Stakeholders from NGOs	Shri. Balwantrai Mehta Panchayatiraj Kendra, Shantivan, Panvel Seal Ashram, Vangani, Panvel Society for Services to Voluntary Organizations, Nerul	25 4 1
4.	Government Official	Public Health and Engineering Department, Panvel	1
5.	Project team	SIES Indian Institute of Environment Management, Nerul	4
	Total participants		98

Total 98 participants including 60 students, 24 stakeholders from NGOs and government officials have participated in training programme.Out of total 98 respondents 64

Plate 50: Photograph of the venue of fourth Awareness programme at Shantivan on 12th September 2014

Plate 51: Registration of Student participation at Shantivan

questionnaires were selected for analysis because they were completely filled for pre and post knowledge assessments as well as all the questions were answered.

A positive and significant correlation was not observed in between independent variables (age, sex, education and source of drinking water) and knowledge about the water contamination and disinfection technologies at 95% confidence interval of correlation coefficient before training (Table- 41). This depicted that respondents were not aware about the problems associated with water contamination and techniques for purification. This confirms that training on water contamination and purification techniques would help in the improvement of knowledge of selected respondents.

Table 41: Correlation between independent variable and knowledge level of respondents

Sr. No.	Dependent variables	Independent variables			
		Age	Sex	Education	Source of drinking water
1.	Common diseases from contaminated drinking water	0.0856	0.0617	0.110575	-0.3305
2.	Sources of Drinking water contamination	0.0676	0.2604	-0.22906	-0.24267
3.	Methods used for disinfection of drinking water	-0.0190	0.02060	-0.00036	-0.33201
4.	Water can be disinfected by boiling	-0.2223	-0.0788	-0.02351	0.1447
5.	Water should be filtered properly to remove turbidity before SODIS	0.1794	-0.0623	-0.205776	-0.1406
6.	Use of Chlorine tablets for water disinfection at household level	-0.0507	-0.0989	-0.25328	0.1994
7.	copper or silverware can effectively kill bacteria	0.0165	-0.0188	0.08511	-0.2244

Improvement in knowledge level was observed with the training programme (Figures 72- 81; Table 42). Before training maximum participants indicated that the major source of drinking water contamination is untreated sewage followed by industrial effluent, leachate and dirty utensils, respectively (Figure 72). After training the knowledge level was improved

Plate 52: Students listening with rapt attention to the proceedings at Shantivan

Plate 53: Villagers and students listening to the lecture by Project Team at Shri Balwantrai Mehta Panchayatiraj Jagruti Kendra Shantivan, Panvel

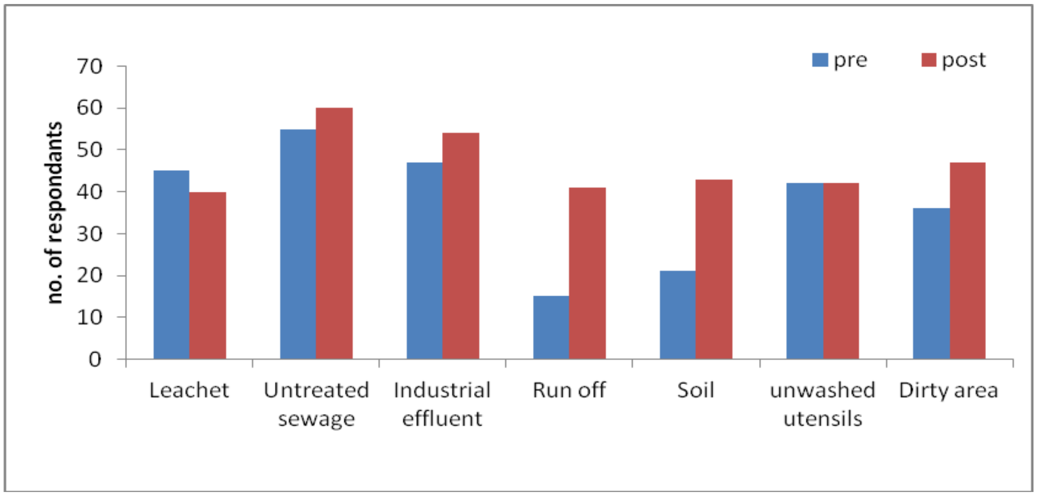


Figure 78: Pre and post knowledge about the sources of drinking water contamination

Maximum participants reported that turbidity is the main criteria for the identification of water impurities followed by odour and unpleasant taste (Figure- 73). After training also knowledge level was significantly improved. Participants were aware about the diseases caused by contaminated water (Figure 74). Knowledge was further improved with the training. Boiling was reported to be the commonly known method for the purification of drinking water at household level by participants; however, after training they were aware about other methods also (Figure-75). Filtration cannot remove impurities completely is known to participants and their knowledge particularly about SODIS and use of metal wares for disinfection was improved (Figure-76)

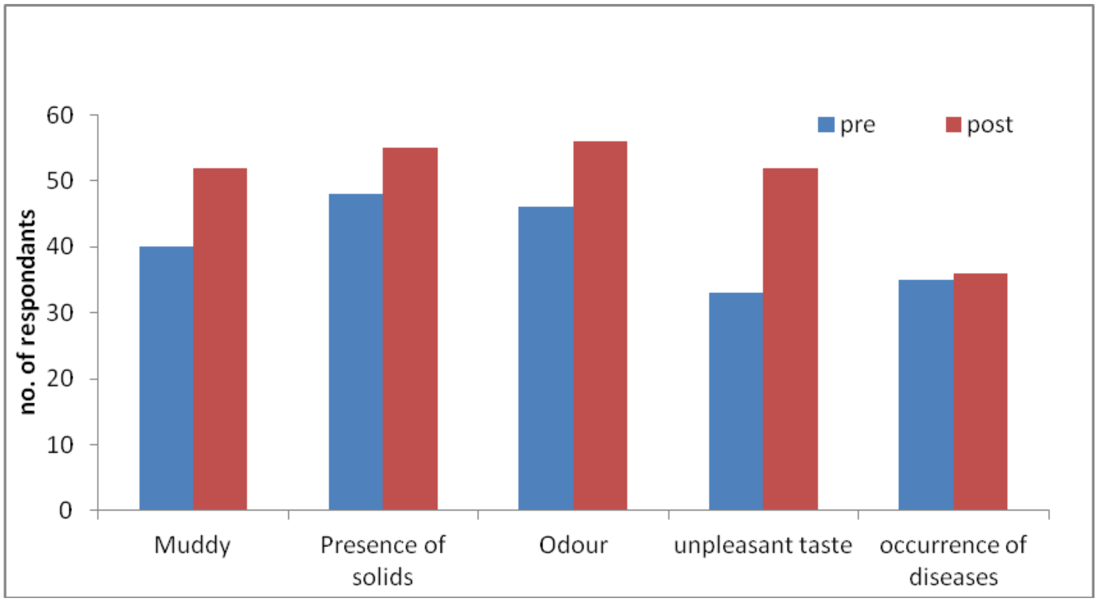


Figure 79: Pre and post knowledge about the detection of water contamination by observation

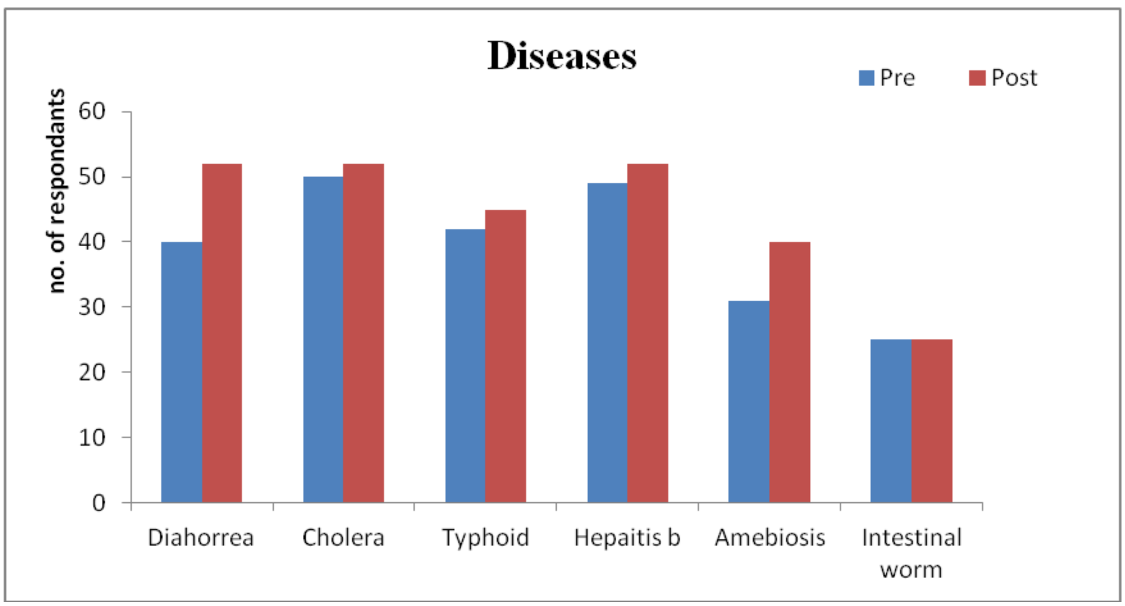


Figure 80: Pre and post knowledge about the common diseases from contaminated drinking water

Plate 54: Showing video clippings on water conservation and hygine- prepared by Ministry of Rural Development, GoI

Plate 55: Participants filling up questionnaires after the lectures

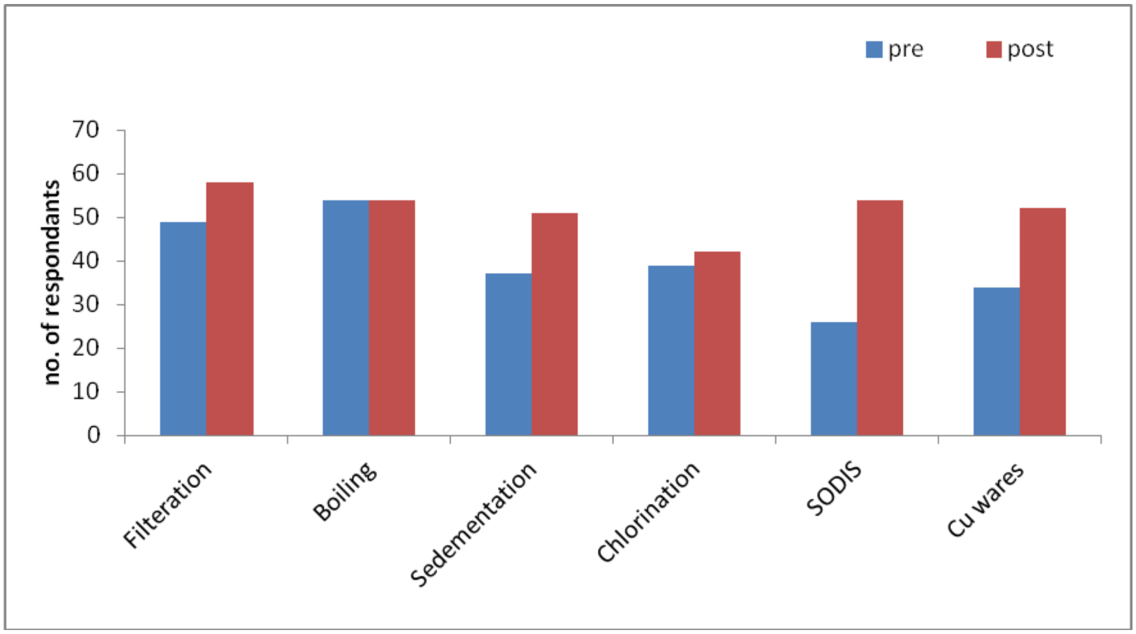


Figure 81: Pre and post knowledge about the methods of disinfection of water at household level

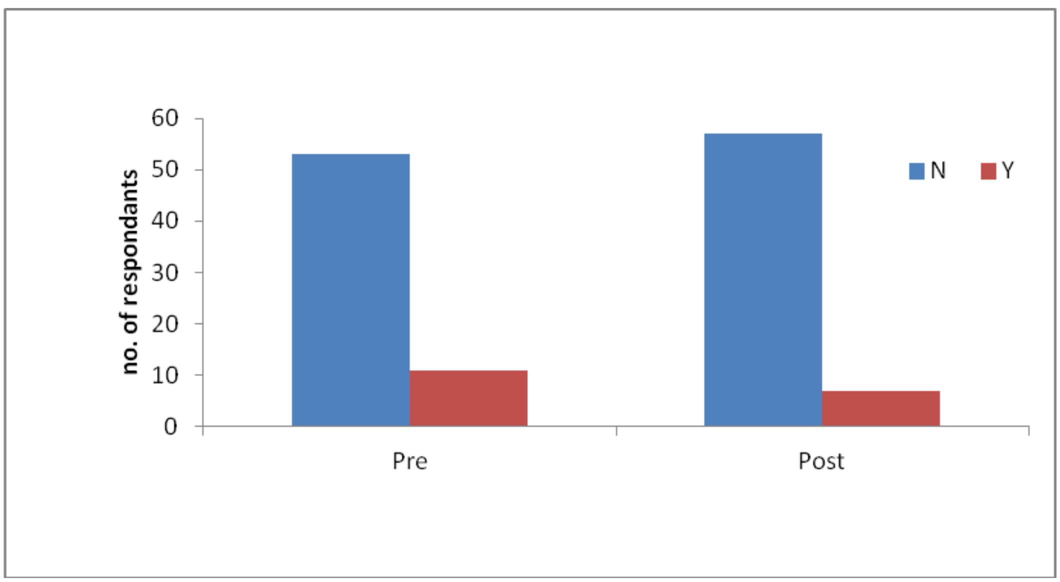


Figure 82: Pre and post knowledge about the filtration of water for removing microbial contaminants

Participants were not aware about the time required for the boiling of water to remove microbial contamination. After training the knowledge is observed to be increased (Figure 77). Participants had clear idea in the mind to filtrate water before SODIS to improve the penetration of sunlight. With training knowledge was further improved (Figure 78).

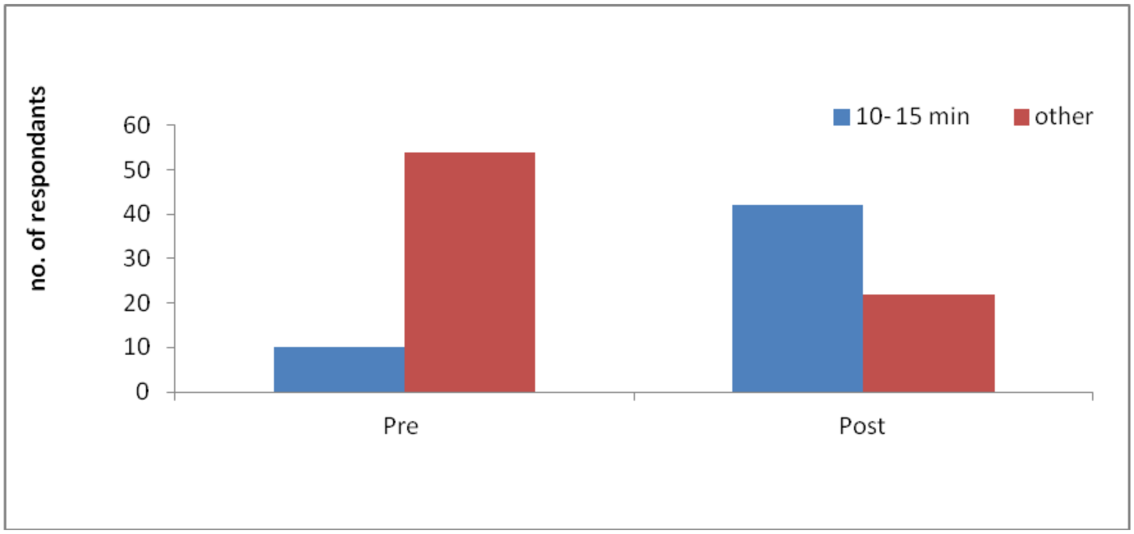


Figure 83: Pre and post knowledge about the time required for disinfection of water by boiling

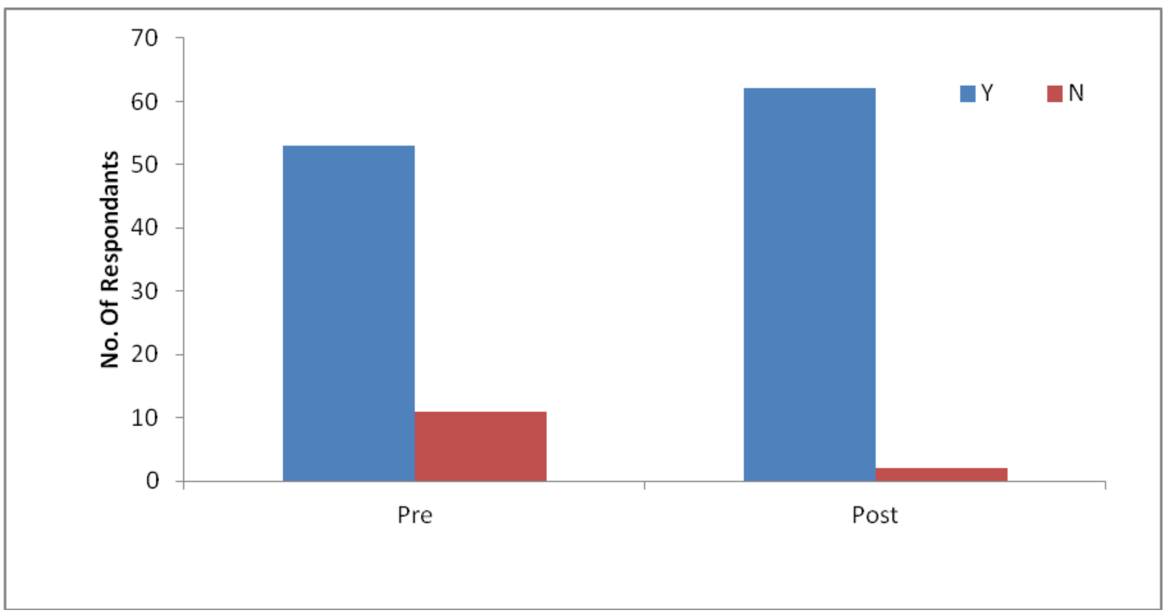


Figure 78: Pre and post knowledge about the filtration of water before SODIS

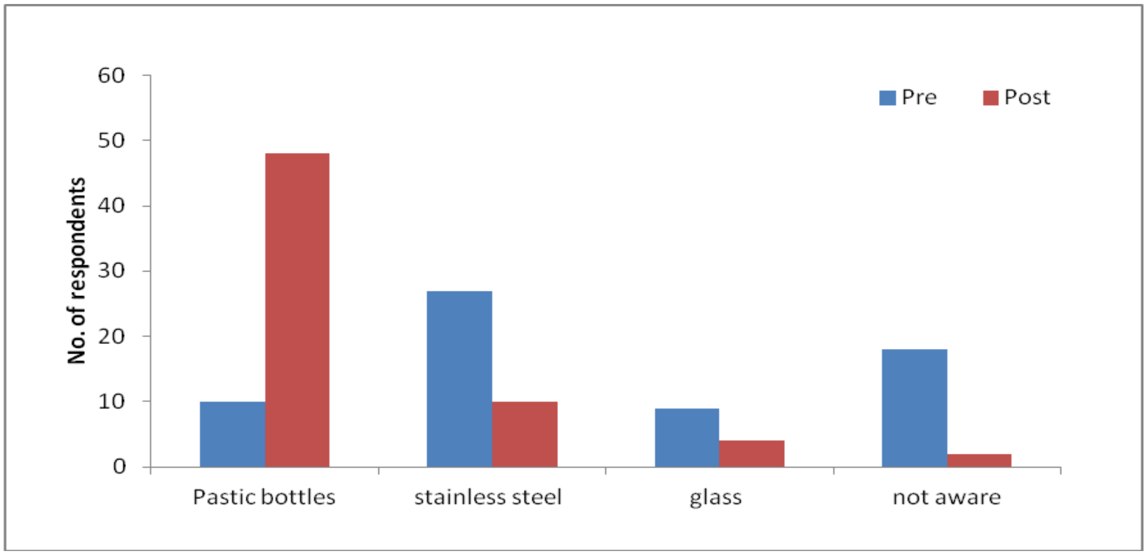


Figure 79: Pre and post knowledge about the type of bottles used for SODIS

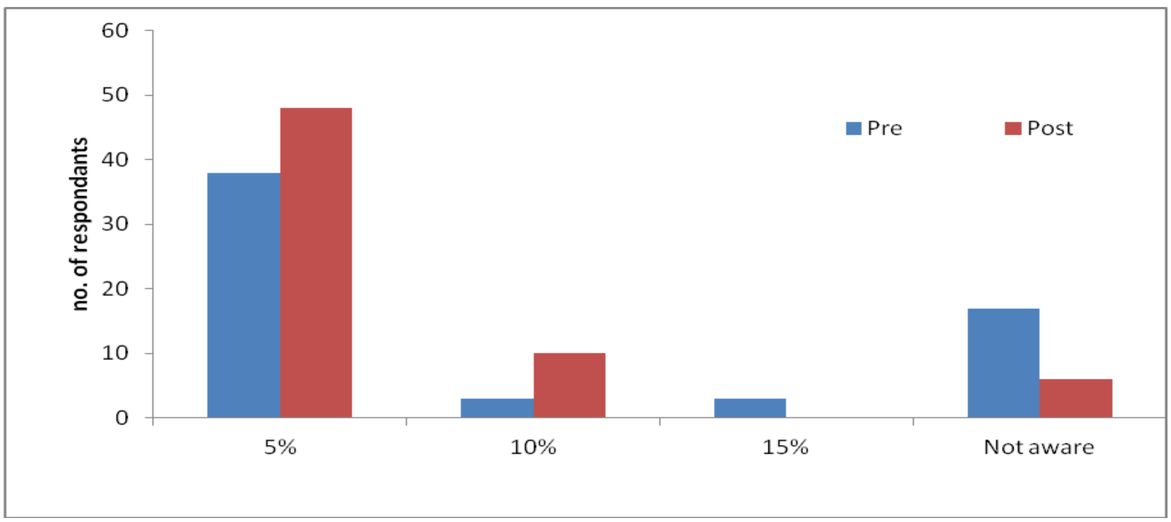


Figure 80: Pre and post knowledge about the concentration of Chlorine Tablets/drops for water disinfection at household level

Majority of participants were in favour of stainless steel bottles for the SODIS, however, after training they were observed to be well aware about the suitability of plastic bottles for SODIS (Figure 79). Knowledge about the concentration of chlorine for the disinfection was significant in participants. It could be due to the intensive promotion of chlorine drops in rural households by government. Students were better aware about it after training (Figure 80).

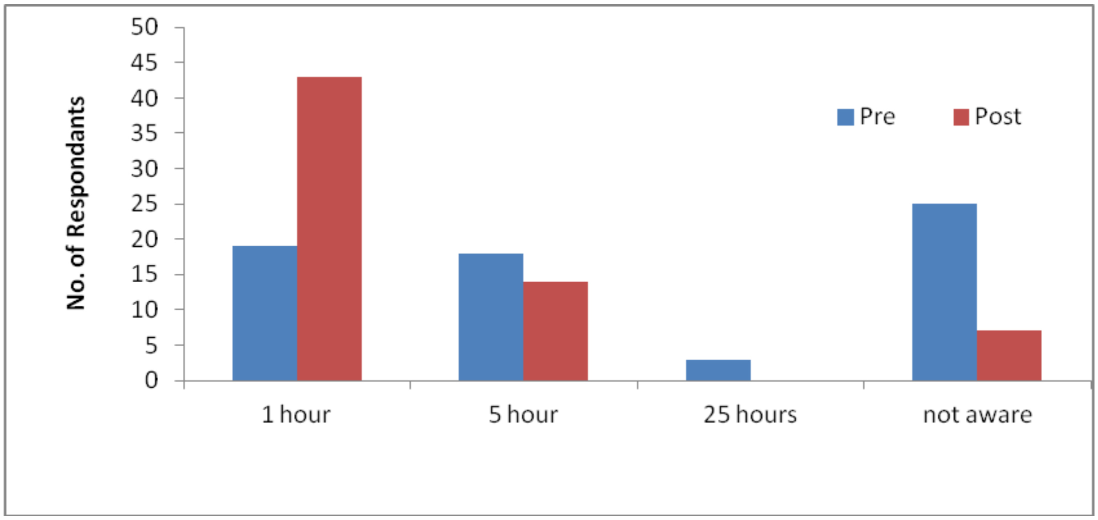


Figure 81: Pre and post knowledge about the disinfection of water by silver and copper metals

Table 42: Pre and post knowledge level of respondents before and after trainings on selected areas

Sr. no.	Variables	Mean Score of Pre Test	Mean Score of Post Test	't' value
1.	Common diseases from contaminated water	2.50	38.44	1.99
2.	sources of drinking water contamination	1.96	1.44	1.99
3.	Methods used for disinfection of drinking water	1.96	1.00	1.99
4.	Filtration by cotton clothes removes microbial contamination	1.44	1.00	1.99
5.	Water should be properly filterd before SODIS	1.69	1.00	1.99
6.	Chlorine drops/tablets for water disinfection at household level	2.89	1.96	1.99
7.	Copper or silver ware can effectively kill bacteria in	4.41	1.96	1.99

*Significant at P< 0.10 level (2- tailed)

It is apparent from Table 41 that knowledge level of respondents was significantly improved (p<0.10) with the training programme. Thus, training programme had positively improved the knowledge level of respondents. After training programme students were better aware about the best exposure time for SODIS (Table 42).

Plate 56: Participants showing interest in Posters displayed during the event

Awareness Programme No. 5

A one day workshop on the topic, 'Water Supply, Quality Assessment, Treatment and Management' was organised on Friday, 31st October 2014 at SIES Educational Complex, Nerul, Navi Mumbai. Total 75 delegates registered from different environmental consultancies and colleges.

The chief guest of inaugural session was Shri. S. K. Chotaliya, Additional Chief Engineer, CIDCO, Navi Mumbai and Guest of Honour was Mr. Subodh Bedre, Governing Council Member, SOSVA. Workshop welcome address was delivered by Dr. V. Ramachandhran, Associate Director, SIES- IIEM wherein he briefed about the SIES group and achievement of SIES- IIEM in the fields of research and development in the fields of water management. Mr. M. V. Ramnarayan, SIES Management Council Member delivered about the concept of workshop and stressed on the need of total water management. Mr. S. V. Viswanathan, Management Council Member, SIES while giving special address in inaugural session emphasized on the water quality management and role of common people in it. Shri. S. K. Chotaliya, Additional Chief Engineer, CIDCO, Navi Mumbai while inaugurating the conference presented the activites performed at City and Industrial Corporation on water management. He highlighted about the need of water management in Navi Mumbai due to gap in water availability. Special Guest Address was delivered by Mr. Subodh Bedre. He stressed on the need of awareness generation on water management in schools and at community level for conservation of water resources.

Total six special lectures were organised on different aspects of water management. First lecture was delivered by Mr. Sandeep A. Adhyapak, M.D., Waterfields Technologies Pvt. Ltd., Thane on the topic, 'Planning and management of bore wells in non-municipal and municipal areas. He briefed about the technologies in the identification of ground table for borwell digging and its management. He stressed on the recharging of borewells by rain water harvesting.

Second lecture was delivered Dr. Ajit Gokhale, M. D. Natural Solutions, Mumbai on the topic, 'Management of sewage and sullage water: Opportunities for recycling and reuse. The potential of reed bed technology in the water management was presented by him.

Plate 57: Inaugural Function of One Day Workshop on Water Supply, Quality Assessment, Treatment and Management held in SIES Complex, Nerul

Plate 58: MPCB Official addressing the participants during our One day Workshop at SIES

Image 59: City Engineer NMMC speaking to participants about during our One day workshop at SIES

Plate 60: Participants during inaugural session of workshop

Plate 61: Lecture on bore well management by Mr. Sandip Adhyapak

Plate 62: Presentation on waste water management and water less sanitation

Third lecture was delivered by Ms. Rupa Avinash, Manager Technology, Ion Exchange (Ind.) Ltd., Navi Mumbai on the topic, 'Drinking water storage and low cost purification for prevention of diseases'. In her lecture she elaborated on different technologies viz. UV, reverse osmosis etc. in drinking water management. She also presented about different products of Ion Exchange in drinking water purification.

Fourth lecture was delivered by Mr. Arun Sapkale, Waterfields Technologies Pvt. Ltd., Thane Conservation of water in non- municipal areas. All the technical aspects involved in rain water harvesting was presented by him.

Fifth lecture was delivered by Dr. Chandrashekhar Shankar, Director, Vision Earthcare Pvt. Ltd. SINE, IIT Powai, Mumbai on the topic, 'Technologies for Waste Water Reuse and Waterless Sanitation'. He demonstrated his work on soil based technology for waste water management as well as waterless and odourless sanitation.

Sixth lecture was delivered by Dr. B.S. Bavaskar, Chief Health Officer, CIDCO, Navi Mumbai on the topic, 'Quality assessment of drinking water for proper management of water borne diseases'. He has given a detail information on the seasonal and epidemic water borne diseases and their management.

The lecture sessions were followed by Plenary cum valedictory session. The Chief Guest of Plenary cum Valedictory session was Sri. Mohan Dagaonkar, City Engineer, Navi Mumbai Municipal Cooperation. The Guest of Honour was Dr. Y. B. Sontakke, Joint Director (Water), Maharashtra Pollution Control Board, Mumbai. Dr. V. Ramachandhran welcomed guests and invited them for lectures. Mr. Mohan Dagaonkar in his speech briefed about the activities of Navi Mumbai Municipal Cooperation in water management. Dr. Y. B. Sontakke briefed about the management of waste water from household as well as industrial units. He stressed on the utilization of recycled water at household as well as industrial level. Dr. V. Ramachandhran gave concluding remarks and Ms. Apoorva Worlikar presented Vote of Thanks at the end of Valedictory session.

Overall Impact of Awareness Generation Programmes

1. The design, approach and strategy of the project were planned in such a way so that all the stakeholders were involved in the activities throughout the project lifecycle.
2. Participation of local NGOs viz. Sri. Blawantrai Mehta Panchayatiraj Jagruti Kendra, Shantivan, Seal Ashram, Gram Vikas Samity, Society for support to voluntary Organizations (SOSVA); Schools viz. Sri Annabhau Sastrabuddhe Anudanit Ashramshala, Wakadi, Panvel, Waje High School, Waje and Nere High School Nere; Gram Sabha members and villagers from 4 villages- Vangani, Usurli, Chinchovli and Bhanghar since beginning of project to last helped us to know major problems associated with drinking water in that area as well as given us a scope to solve problems through awareness generation programmes. Several case studies would reflect light on this-

Case Study 1: - While interacting with Seal Ashram personnel regarding problems with drinking water it was observed that they had major problem in sewage and sullage water management. Waste water was accumulating near their premises and creating problems of mosquitoes and other pests. Moreover, they were getting ample amount of rain water through nearby hills but they were not aware to use it. Wastewater and drinking water mixing was adding to health problems in the inhabitants of ashram. We had invited and involved Seal Ashram people in our awareness generation programmes and it was observed that they were satisfied and with the help of agencies identified by us they have planned for proper management of waste and drinking water.

Case Study 2: At Vangani Village in Nere, Panvel majority of inhabitants were having water purification units in their households but they were not maintaining it that is resulted in health hazards among inhabitants. Gram Sabha was distributing chlorine drops among villagers with the support of Public Health and Engineering Department of Panvel. But people were not aware about the proper dosage of chlorine for water purification. Majority of people reported excess dose of chlorine during discussion. We had made them aware about the ill effects of excess dosage of chlorine in water. The Sarpanch had regularly checked water quality with the help of PHE Department; however they were not aware about the significance of physical, chemical and biological parameters as well as standard range. After attending our training programmes they were quite satisfied and took our training materials for their future use.

3. In villages viz. Vangani, Usurli and Chincholi it was observed that bore wells were prepared at very close distance and sewage pits were also nearby. Although at present villagers are not facing any problem but in future ground water quality will deteriorate. On pointing to this problem villagers asked us for help. We have supported them by providing information from experts.
4. During awareness generation programmes demonstration of drinking water analysis through testing kits generated interest of stakeholders in on the spot testing of water samples (Plate 43). In this way they learnt better about physical, chemical and microbial parameters of drinking water by performing analysis.
5. Analysis of pre and post knowledge feedback (Figures 26 to 81; Tables 39 & 42) clearly indicated that knowledge level of stakeholders was significantly improved after trainings. Improvement in knowledge after training programme was proved by two tailed T test that was highly significant at $p<0.01$ level of significance.
6. In each training programme representatives from different government departments were invited for lectures that helped us as well as stakeholders in knowing government schemes as well as role in drinking water management.
7. Participation of local NGOs, teachers from schools as well as Gram Sabha Members with ensure sustainability of project objectives for long time.
8. The results obtained in study will support future endevours of different government departments’ viz. MMRDA, CIDCO, Raigad Municipal Corporation and Public Health and Engineering Department of Raigad district in planning and implementation of projects related to pure drinking water.
9. Further, by publishing news about over training programmes in local newspapers (refer pg. 120 & 130) helped in the wide circulation of message especially in areas which were not involved in the project.

News of Awareness Generation Programmes Published in Local Newspapers

रायगड जिल्हा आणि नवी मुंबईचे अग्रेसर वृत्तपत्र
दैनिक
किल्ले रायगड
पनवेल
संपादक : प्रमोद लक्ष्मण वालेकर
मंगळवार दिनांक २३ सप्टेंबर
Email: killeraigad@gmail.c

शांतिवनात जलशुध्दीकरण व्यवस्थापन शिबिर

पनवेल दि.२२ (प्रतिनिधी) : एसआयईएस इंडियन इन्स्टिट्युट ऑफ एनवॉयरमेंट मॅनेजमेंट, नेरुळ आणि कुष्ठरोग निवारण समिती संचालित बलवंतराय मेहता पंचायतराज जागृती केंद्र, शांतिवनच्या वतीने एक दिवसीय जलशुध्दीकरण व त्यांचे व्यवस्थापन शिबिर संपन्न झाले.

प्रकल्पक्षेत्रातील वाजे, केवाळे हायस्कुलमधील विद्यार्थी शांतिवन आश्रमशाळा तसेच ग्रामस्थांसाठी हे शिबिर घेण्यात आले. शिबिराचे उद्घाटन संस्थेच्या विश्वस्त व उपाध्यक्षा रक्षा मेहता यांनी केले त्यांनी प्रास्ताविकपर सर्वांना मार्गदर्शन केले.

यानंतर एसआयईएसचे डॉ. वी रामचंद्रन यांनी पिण्याच्या पाण्याचे श्रोत्र व त्याचे व्यवस्थापन कसे करता येईल यावर सविस्तर माहिती दिली. तर एसआयईएसचे डॉ. शीघा मिश्रा यांनी पिण्याचे पाणी प्रदूषित होण्याची कारणे व त्या संबंधित होणारे रोग याची माहिती दिली.यानंतर योगेश म्हात्रे यांनी स्लाईड शो व पाण्यासंदर्भातील फिल्म दाखवून शाळेतील मुलांना व ग्रामस्थांना पाण्याचे महत्व पटवून दिले.यानंतर संस्थेचे कार्यवाह विष्णु प्रभुदेसाई यांनी प्रशिक्षणार्थीशी चर्चा केली व त्यांच्या प्रश्नांना समाधानकारक उत्तरे दिली. शिबिराचे सुत्रसंचालन बलवंतराय मेहता पंचायतराज जागृती केंद्राचे समन्वयक संजय गुळुंबकर यांनी तर आभार एसआयईएसचे अपुर्वा वाळीकर यांनी मानले.

रायगड जिल्हा आणि नवी मुंबईचे अग्रेसर वृत्तपत्र

रामप्रहर
शुक्रवार, दि. १९ सप्टेंबर २०१४ २

शांतिवनात जलशुध्दीकरण शिबिर

पनवेल : रामप्रहर वृत्त

एस. आय. ई. एस. इंडियन इंस्टिट्युट ऑफ एनवॉयरनमेंट–नेरूळ आणि बलवंतराय मेहता पंचायत राज जागृती केंद्र–शांतिवन यांच्या संयुक्त विद्यमाने नुकताच विद्यार्थी व ग्रामस्थांसाठी जलशुध्दीकरण व त्याचे व्यवस्थापन या विषयी एक शिबिर घेण्यात आले. पनवेल तालुक्यातील वाजे, केवाळे हायस्कूल व शांतिवन आश्रमशाळेतील विद्यार्थी तसेच प्रकल्पक्षेत्रातील ग्रामस्थ या शिबिरात सहभागी झाले होते.

कुष्ठरोग निवारण समिती संस्थेच्या शांतिवन विश्वस्त व उपाध्यक्षा रक्षा मेहता यांनी या शिबिराचे उद्घाटन केले. एस आय ई एस इंडियन इंस्टिट्युट ऑफ एनवॉयरनमेंटचे डॉ. व्ही. रामचंद्रन यांनी पिण्याच्या पाण्याचे स्रोत व त्याचे व्यवस्थापन कसे करता येईल, याची सविस्तर माहिती दिली. डॉ. सीमा मिश्रा यांनी पिण्याचे पाणी प्रदूषित होण्याची कारणे व त्यामुळे होणारे रोग याविषयी माहिती दिली. योगेश म्हात्रे यांनी स्लाईड– शो व पाणी संदर्भातील फिल्म दाखवून विद्यार्थ्यांना व ग्रामस्थांना पाण्याचे महत्त्व पटवून दिले.

संस्थेचे कार्यवाह विष्णू प्रभुदेसाई यांनी प्रशिक्षणार्थींशी चर्चा केली व त्यांच्या प्रश्नांना उत्तरे दिली. या शिबिराचे सूत्रसंचालन बलवंतराय मेहता पंचायत राज जागृती केंद्राचे संजय गुळुंबकर यांनी केले. एसआयईएस इंडियन इंस्टिट्युट ऑफ एनवॉयरनमेंटच्या अपूर्वा वरळीकर यांनी आभार मानले.

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CONCLUSIONS

Approved objectives of the project are to identify the water sampling locations such as open tanks, wells, common taps and tanker supplied water in the selected villages in Navi Mumbai under MMRDA jurisdiction region, to conduct physical, chemical and microbial analysis of the water samples collected, to study disinfection on the collected samples by various disinfection methods , to impart knowledge to the students regarding potential sources of contamination and risks associated with it and to create awareness about water purification and testing technologies among the nearby school children as well as among the villagers. All the objectives mentioned in our proposal have been successfully executed.

A survey was conducted to identify problems associated with drinking water, its source, its purification technique and the general knowledge level of the population. The survey included 170 participants comprising both school children and villagers. Sources of drinking water is observed to be from the underground water only drawn by borewell, hand punp or open well. The water directly drawn from these do contain microbial contamination but at lower levels. The microbial content varies with season. Contamination is observed in locations where previously no contamination is seen. Stored waters invariably have more contamination due improper cleaning and personal hygiene. Hand pumps go dry during summer. Open wells are heavily contaminated and not maintained. They are generally abandoned. Out of 150 respondents 112 said that toilet is available at home while 38 respondents said that they don't have toilet at home. Out of 117 respondents 109 said that the toilet discharge is directly connected to a septic tank.

A field survey of the various villages beyond Panvel was made to identify water sampling locations. Sampling location for the analysis of water samples, to check for the quality of drinking water was also done. Total of 5 villages and 3 schools were identified for the study. Three sets of drinking water samples were collected from the above mentioned locations at different times and designated as Post monsoon, pre monsoon and monsoon samples.
The sample numbers are given in Table 2. Table 3 gives the number of samples collected in different seasons.

Turbidity values varied in the range of 0.3 to 8.6 NTU. pH of these water samples varied from 7.25 to 8.69. Electrical conductivity values ranged from 0.178 to 0.904 mS cm-1. Total dissolved solids varied from 118 ppm to 600 ppm. Total Alkalinity values ranged from 57.8 to 208 mg $CaCO_3$ /L. Free carbon dioxide values were found to be in the range of 0.013 to 6.44 mg/L. Dissolved Oxygen values were in the range of 0.99 to 4.07 mg/L. Total hardness values varied in the range of 19.98 to 399.8 mg $CaCO_3$ /L. Chloride values were in the range of 13 to 125 pmg/L. Sulphate values varied in the range of 3.8 to 117 mg/L. Nitrate values were to be in the range of 0.4 to 5.7 ppm while several samples showed below detection level. Fluoride concentration were in around 0.1 ppm. Arsenic concentration was in the range of 0.6 ppm. Calcium concenatrtion varied in the range of 4.5 to 56 mg/L Magnesium values were comparatively lower in the range of 0.1 to 21 mg/L. Manganese concentrations were less than 0.1 mg/L. Zinc Concentrations were also very low., always less than 1 mg/L. Iron and Copper concertinos were below detection levels. Samples showed minor variations in physical, chemical and microbial contamination levels with season. Around 50% of the drinking water samples are found to have microbial contamination. The contamination level increased generally with time. Microbial contamination was observed to increase with pasasage of time in most of the cases though the reverse trend was noticed in one location. Two locations showed presence of contamination which was not noticed before. These samples microbial strains were were found to be contaminated with E.coli and Klebsiella.

Disinfection trials were carried out on contaminated drinking water samples using solar disinfection, chlorination and boiling methods. Solar disinfection was carried out by keeping the contaminated water samples in clear transparent plastic containers and keeping their exposed in horizontal position for varying durations of time. Chlorination was done by adding sodium hypochlorite solutions. A stock solution of 4% sodium hypochlorite solution was made, assayed for chlorine content using standard methods and suitably diluted to the required level using sterilized reagent water. Measured dosages were added to contaminated samples and mixed thoroughly for fixed time durations. Disinfection by boiling was carried out by keeping the contaminated water samples in glass bottles in a temperature controlled water bath. The extent of disinfection by different methods were followed by spread plating method and results expressed as cfu/ ml. It was seen that 30 minutes exposure to a bright day light in clear plastic containers completely disinfects the drinking water sample in all cases. 10 ppm chlorine addition and agitating for 30 minutes is found to totally disinfect the drinking water samples. Keeping contaminated water samples for 5 minutes at 80^0C is enough to disinfect the contaminated drinking water samples.

Awareness generation programs are conducted in the project for assessing the problems associated with drinking water and imparting knowledge about the low cost household water purification techniques. In order to identify the problems associated with the drinking water in the area a survey was conducted by involving 120 villagers and students in the selected area. Pre and post knowledge survey was done before and after each training programmes in order to assess the improvement in the knowledge level of participants before and after training. The survey formats were statistically analyzed to get significant level as well as correlation between the independent and dependent variables.

Four awareness programmes were conducted in three schools, namely Vaje High School, Vaje, Panvel and Nere High School, Nere, Panvel on 24th March, 2014 and Shri. Annabhau Sahastrabudhhe Anudanit Adivasi Asharamshala, Wakdi, Panvel, Raigad on 12th July 2014 and in Shri Balwantrai Mehta panchayatiraj juagruti Kendra, Shantivan on 12th September 2014. A full day Workshop on Water Supply, Quality assessment, Treatment and Management was organized at SIES Educational Complex on 31st October 2014. Posters were made on the importance of water and causes of water pollution and a general awareness talk was delivered in each school. Every student and teachers were given pamphlets and one poster each in schools on the topic, 'water pollution, its hazards and disinfection techniques'. Pre and Post Awareness feedback forms were collected from the participants and their responses were analyzed for significance on the basis of their completeness and understanding. Demonstration of water quality testing for following parameters was done before students and teachers: pH, Chloride, residual chlorine, fluoride, iron and nitrate. Statistical analysis has been carried out on the response data collected from students of from Shri. Annabhau Sahastrabudhhe Anudanit Adivasi Asharamshala, Wakdi and at Shri Balwantrai Mehta panchayatiraj juagruti Kendra, Shantivan. From the statistical analysis of the data it is found that the knowledge level of respondents was significantly improved ($p<0.10$) with the training programme. Thus, training programme had positively improved the knowledge level of respondents.

RECOMMONDATIONS

- Water quality assessment needs to be carried out in a sustained manner in villages as the microbial quality of drinking water is getting progressively poor.
- Extensive use of underground water is being pumped out in villages and a concerted effort to educate the villagers on the need to ensure rain water harvesting.
- Government approval before digging bore wells should be mandatory.
- Microbial test kits for free potable water quality assessment needs to be provided in all village Panchayat offices and periodic awareness programmes on ensuring acceptable water quality should be conducted.
- Low cost disinfection techniques need to be propagated as a safe and reliable method of disinfection of potable water. Some specific recommendations for techniques are as:-

- **For Boiling:**
  - i. It is effective in controlling all classes of waterborne pathogens (bacteria, virus, protozoa and spores of bacteria, fungi and ova of helminthes). Once water starts boiling 1-5 mutes of rolling boil is sufficient to attain disinfection. This observation is in confirmation with WHO guidelines, 2002.
  - ii. Water should be covered by lid and remained in same container in which it is boiled to prevent it from recontamination.
  - iii. As per WHO guidelines boiled water should be consumed by same day.
  - iv. It is best method for water disinfection in rainy season, however, if there is a problem of fuel than chlorination or SODIS could be utilized.
- **For Chlorination:**
  - i. Always use chlorine in the form of drops as per the dose and time mentioned on the bottle. As per standard dose 25 ml of chlorine solution is required to disinfect 1000 L of water (WHO, 2002). So, for 10 L 0.05 ml of solution is required that is equivalent to 2 drops because 1 drop usually contains 0.025 ml of chlorine liquid.
  - ii. Twenty to thirty minutes are sufficient to get complete disinfection.
  - iii. Narrow mouth plastic container is best because in metal containers chances of corrosion increases. Also, narrow mouth prevents recontamination of stored water.
  - iv. Never use powder bleach for disinfection as it may contain other undesirable compound as well as it is difficult to know proper dose required for disinfection.
  - v. Do not drink chlorinated water incase of strong smell and taste. High dosage of chlorine in water may cause asthma or dermatitis.

- **For SODIS:**
  i. Effective, easy and economical method for disinfection.
  ii. For rainy season this technique is not recommended for disinfection of drinking water.
  iii. Filter water before filling in bottle to remove solid particles.
  iv. Plastic bottles kept in direct sunlight between 11 am to 4 am are most suitable time.
  v. Complete disinfection may be achieved within 2-3 hours.
  vi. Keep bottles on black surface or paint one side of bottle black in colour for fast and complete disinfection.
  vii. Use clear and clean bottles. Wash them properly before use.
  viii. If bottle surface is turning rough it is advisable to discard it.

- ❖ Localized sewage treatment methods need to be seriously considered and implemented to improve overall sanitation.

Scope for Future Work

- ❖ Replication of work in interior villages especially in tribal areas.
- ❖ Screening of ground water level at different places to know about the profile of water.
- ❖ More knowledge sharing on clean water and waste water management.
- ❖ On the field study on disinfection studies for better understanding as well as knowledge of villagers.
- ❖ To do extensive work for the adoption of low cost methods for drinking water disinfection in correct way.

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