

# Assessment of the Impact of Swachh Bharat Abhiyan on the Quality of Soil and Water Sources in and Around Dindigul, Tamil Nadu

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**Abstract:-** Swachh Bharat Abhiyan is a massive movement that seeks to create a clean India. The impact of this programme in Dindigul district was assessed by analyzing physico-chemical and biological parameters of ground water in and around Dindigul to check the quality of water and its suitability for domestic purpose. Open wells, hand pumps, mini power pumps and dam water are the water resources of the study area. Fifty three samples from different sources with special reference to open defecation and non open defecation locations were collected in post monsoon season of 2016. Twenty two water quality parameters were studied. The results were compared with the standard values prescribed by BIS. To find the impact of government level intervention on the environmental quality, presence of fecal indicator bacteria in soil and drinking water sources were studied and compared with the data available before the launch of Swachh Bharat Abhiyan. The present investigation revealed that the quality of water varies from location to location and some of the water samples are unfit for drinking and utility purpose. The microscopic observation of soil sample revealed the presence of helminth eggs as *Ascaris lumbricoides* eggs (both fertile and infertile) as well as that of *Trichuris trichiura* (whipworm) eggs, an indication of fecal contamination.

**Key words:** Swachh Bharat Abhiyan, water parameters, *E-coli*, helminth

## 1. INTRODUCTION

Swachh Bharat Abhiyan is a national campaign by the Government of India, covering 4041 statutory towns, to clean the streets, roads and infrastructure of the country. The main objective of this Swachh Bharat Abhiyan (SBA) is to improve the standard and quality of life in the rural areas. The government is committed to achieve this vision by 2nd October 2019[1]. Government of India had restructured the Comprehensive Rural Sanitation Programme as a whole with effect from 1st April 1999 and launched the Total Sanitation Campaign (TSC) which was a continuation of the previous one. It was renamed Nirmal Bharat Abhiyan (NBA) later, on 1st April 2012. A very meager percentage of (about 22%) of the rural families had access to toilets in 2001. But the Total Sanitation Campaign could improve this situation upto 32.70% as per the readings of 2011 census. If we go further we can see 40.60% rural households have toilets [2].

Diarrhoeal death is chiefly caused by open defecation as per the inference reached by WHO after their deep study conducted in 2014. Number of people practicing open defecation in 1990 was 1.3 billion. This rate of percentage fell by 21% and reached one billion in 2012 and 82% of this one billion practicing open defecation in the world live in 10 countries including India. India tops the list of countries with highest number of people practicing open defecation [3] when the rest of the world is giving stringent attention to steadily eliminate this habit. The 2011 census shows that 67% of rural households and 13% of urban households are practicing defecation in the open. India alone accounts for 60% of the world's open defecation as per the reports of the studies by WHO and UNICEF in 2014. Another inference is that an estimated 4.5 billion people are at the risk of infection due to the three common soil-transmitted helminthes, viz., the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*), and the hookworm (*Ancylostoma duodenale* and *Necator americanus*)[5,6].

Sikkim became the first state which declared Open Defecation Free (ODF) according to the report of the secretary for Ministry of Drinking water and Sanitation (MDWS) of India. This was followed by Himachal Pradesh and Kerala. It is a sorry state of affair that the state of Tamil Nadu is not even in the expected list. As far as health and sanitation is concerned, Cuddalore, Thiruvattiyur, Dindigul and Thoothukkudi cities need immediate remedial action and this should be done speedily. If there are any municipalities which cross the redline, they need special attention [4].

Physico- chemical parameters for ground water samples of Dindigul corporation in summer and rainy seasons for three successive years [2011-2014] were studied by Mohammed Hanipha et al[16]. Zahir Hussain et al analysed physico-chemical parameters for twenty three ground water samples using water quality index in and around Dindigul [17]. Pearson correlation co-efficient for physico-chemical parameters and heavy metals were also studied by Mohammed Hanipha et al[18]. Water quality and correlation studies were conducted by I.N.Karthika et al at selected locations in Dindigul district[19]. There are clear links drawn between the types and levels of specific contaminants in the air or water in many cases, and their

health effects are also studied and recorded. However, the impacts of soil pollution on our health have had a much lower profile until recent studies and inferences are reached. Besides, the science involved is complex. The present study deals with assessing the impact of Swachh Bharat Abhiyaan especially in an open defecation area like Dindigul and the results are compared with similar studies [16] cited above, which were carried out before the launch of SBA.

In this study water samples have been taken for physical, chemical and biological characterization from all the available sources of Dindigul corporation limit to check the quality and suitability for domestic purpose. Microbial analysis was also conducted on soil samples to know the level of helminth contamination. Perusal of literature shows that this is the first study to assess physico-chemical and biological parameters of potable water from all available sources and soil helminth study with special reference to open defecation and to find the influence of Swachh Bharat Abhiyaan in Dindigul corporation limit.

## 2. EXPERIMENTAL SECTION

### 2.1 Study Area

Dindigul Corporation spreads in 104 Sq.km containing 48 wards. The sampling points of the study area were selected after a pilot study to identify open defecation and non open defecation areas. Dindigul is located within 10° 18' to 10° 25' N latitude and 77° 56' to 78° 01' E longitude, covering a total area of 14.01sq.km. (Fig.1).

### 2.2 Sampling Stations

The main water sources of Dindigul Corporation are Mini Power pumps(M.P.P), Hand Pumps(H.P), Open Wells(O.W) and Dam Water(D.W). In the period of study majority of people had to depend on M.P.P and D.W as 90% of the O.W and H.P contained no water. From the available water sources, twelve O.W samples, nine H.P samples and twenty eight M.P.P samples were chosen for the physico-chemical analysis of water in such a way to get the water quality scenario of the entire Corporation area. Among these, biological analysis was conducted for twelve open well samples. Sample sites for biological analysis are R.M.Colony, Narayanpillathottam, Kumaran park, Parapatti, Poochinayakampatti, Lourdmatha school, Vinobaji Nagar, Nagal Nagar, Bharathi Hostel, Vekateswara, M.S.P School, Gopalasamudram.

### 2.3 Sample collection strategy

Samples were collected for this study following standard procedure as described by APHA (1998)[7]. Pre-washed 500 mL sized PVC plastic bottles were used to collect water samples for quality analysis. Samples were collected during the day time between 7.00 to 11.00 am. Sample containers were labeled on the field using appropriate codes and water samples were temporarily stored in ice packed cooler and transported to the laboratory and stored in a refrigerator at about 4°C prior to biological analysis[8]. Physico-chemical analysis had been done within 12 hours of sample collection. These samples were collected

on the post monsoon season of 2016 and the quality and chemical characteristics were determined by standard methods [9- 12]. The pH was determined using a Micro Computer pH meter. Soil samples were collected from eleven different sites including open defecated areas. All samples were collected during early morning. Samples were taken using metal spade and it was then kept in zip packet.

### 2.4 Swachh Bharat Abhiyan program in Dindigul

Swachh Bharat Abhiyan is implemented in the year 2014 and is a five year programme. The main objectives of the programme is in improving the urban sanitation, elimination of open air defecation, creation of awareness about the sanitation, improvement of solid waste management, improvement of using community and public toilets. A midterm evaluation will help to improve the activities mentioned in the plan and was lead to course correction. This study finds work done for building house hold toilets, community toilets, solid waste management system, Individual House Hold Latrines (IHHL) constructions, and activities to make the whole corporation open defecation free.

### 2.5 Physico-chemical and microbial analysis of water samples

All chemicals used were of high purity and analytical grade. The water quality parameters were analyzed using standard analytical methods. Temperature, turbidity and pH were determined on the site itself. Nitrate-nitrogen, nitrite-nitrogen, ammonium-nitrogen, total nitrogen and soluble phosphate, were measured using Hach Lange kits. Standard laboratory methods as described by the APHA (1998) were followed for the examination of water samples for the analysis of total solids, total suspended solids, total dissolved solids, calcium, magnesium and chlorides. Sulphate was determined using Nephelometric turbidity meter (TAHP, 1999). Biological analysis of water was conducted with open well water. Among the available open well sources that contain water, 12 sites were selected from open defecated and non open defecated areas. Most Probable Number (MPN) technique was used to detect the number of total coliforms (*E.coli*) in water samples. Gas production indicates the confirmation of coliform groups [13]. Data for microbial and physico-chemical contaminants in drinking water samples were recorded and analysed for appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, alkalinity, total alkalinity, total hardness, presence of calcium, magnesium, iron and manganese, ammonia, nitrite, nitrate, chloride, fluoride, sulphate, phosphate and oxygen.

### 2.6 Data analysis

Mean and standard deviations were calculated for the results of the three samples per sampling point. Water quality results were compared with the Indian standards [Table 2,3,4&5] and as well as with the results obtained from an earlier study conducted by Mohammed Hanifa et al [16] before the launching of Swachh Bharat Abhiyan [Table 9] in Dindigul corporation limit.

## 2.7 Microscopic observation and characterization of soil samples

Water contamination automatically affects soil quality and vice versa. Information obtained from the pilot study helped to identify open defecation area and were collected samples from 11 sites. pH and type of the soil was tested along with nematodes and cestodes identification.

### 2.7.1 Reagents used

Zinc sulfate solution (33%, relative density 1.18); ether (or ethyl acetate); acetoacetic buffer (pH 4.5), 15 g sodium acetate trihydrate, 3.6 ml glacial acetic acid, made up to 1 litre with distilled water; detergent solution made up to 1 litre with tap water.

### 2.7.2 Equipment

Plastic containers were used for sample collection; a centrifuge and centrifuge tubes with lids (50-ml and 15-ml tubes); Pasteur pipettes and teats; McMaster counting slides (1 or 2); a vortex mixer; a siphon; a 10-ml or 50-ml measuring cylinder or 10-ml graduated pipette.

### 2.7.3 Soil analysis for microbes and pH

*Trichuris trichiura* egg was moved under the eyepiece micrometer scale. If its length was found to cover 8 spaces of the scale using the 10 X objective lense, its real length is can be calculated as  $8 \times 6.7 = 53.6\mu\text{m}$ . The pH of the soil was also calculated (Denver Instrument Company, USA).

### 2.7.4 Procedure

Soil samples were allowed to sediment for 2 hrs in double distilled water. After that supernatant was removed using a suction pump and the sediment was transferred to centrifuge tubes and this was centrifuged at 1000 rpm for 15 min in cooling ultra centrifuge. Then the supernatant was removed and the pellet was suspended in an equal volume of acetoacetic buffer having pH 4.5. The solution was thoroughly mixed in a vortex mixer and centrifuged. The volume of the pellet containing the eggs was recorded, and then poured off the rest of the supernatant.

The pellet was re suspended in five volumes of zinc sulfate solution. The sample was mixed thoroughly using a vortex mixer. After that aliquot was quickly removed with a Pasteur pipette and transferred to a McMaster slide for final examination. Before examination McMaster slide was left to stand on a flat surface for 5 min. Then the sample in the slide was examined through microscope with 10 X magnification. All the eggs were counted within the grid in both chambers of the McMaster slide.

Number of eggs per litre can be calculated from the following equation

$$N = AX/PV$$

Where  $N$  is the number of eggs per litre of sample,  $A$  is the number of eggs counted in the McMaster slide or the mean of counts from two or three slides,  $X$  is the volume of the final product (.2ml),  $P$  is the volume of the McMaster slide (0.3 ml),  $V$  = original sample volume (litres). McMaster slide being used was  $P = 0.3$  ml

## 3. RESULTS AND DISCUSSION

### 3.1 Analysis of SBA program in Dindigul

Before the launching of SBA, most of the 48 wards in Dindigul Corporation were OD area and within two years after implementation of SBA, the Corporation could able to declare 44 wards as open defecation free (**Fig.2**). This can be justified by noting the infrastructural changes happened during the past two and half years, measures taken by corporation officers, the financial support given by SBA and positive changes in the attitude of common people (**Table1**).

### 3.2 Physico chemical analysis

Table 2 shows the values of physico-chemical parameters estimated during post monsoon season. Most of the physico-chemical parameters of Hand Pump (H.P) and Mini Power Pump (M.P.P) samples are well within the permissible limit of Indian standards (**Table 2&3**). Open well water analysis also showed the same trend but chloride level showed wide variation (**Table4**). Analysis of Athur dam water and Kaveri dam water showed that it can be used for drinking purpose (**Table5**). Electrical conductivity (EC) reflects the amount of total dissolved salts [14] and is a useful tool to measure the purity of water. Conductivity shows significant correlation with ten parameters such as temperature, pH, alkalinity, total hardness, calcium, total solids, total dissolved solids, chloride and iron concentration of water. The underground drinking water quality of the study area can be assessed effectively by measuring EC and the values were in the range of 300-6900  $\mu$  mho/cm for M.P.P, 1000-4400  $\mu$ mho/cm for H.P, 1800-7200  $\mu$  mho/cm for O.W and 380-890  $\mu$  mho/cm for D.W. High EC values were observed, indicating the presence of high amount of dissolved inorganic substances in ionized form.

Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed [15]. TDS values in the study area varied from 210-4830 mg/L for M.P.P, 700-3080mg/L for H.P and 1050-5040mg/L for O.W, which were found to be above the limit limits of BIS that is 2000 mg/L, except for D.W (266-623 mg/L). Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values of the present study area ranges from 60-1180 mg/L for M.P.P, 260-820mg/L for H.P, 460-1800mg/L for O.W and 140-260mg/L for D.W. Except dam water sample, all other sources exceed the BIS limit of 200 -600 mg/L. pH and hardness affect the toxicity of many substances in water. In the present analysis alkalinity values were found within the BIS range of 200-600 mg/L.

### Levels of major cations

Calcium is one of the major cations in water. High calcium was registered concentration registered at sample site 13 of H.P.P and at Lourd Matha school, Gopalamudram for O.W. Calcium concentration in dam water was found to be very low and for hand pump samples, the values were found within the BIS limit. Magnesium is directly related to hardness. Magnesium concentration was found within the BIS limit in all the water samples. The

concentration of Iron and Manganese was also found to be well within the range.

### Levels of major anions

The chloride concentration serves as an indicator of pollution by sewage. People exposed to higher chloride in water are face laxative effects. In the present analysis, chloride concentration was found within the limit of BIS, except one place each for M.P and H.P (site 13&11). Except Poochinayakampatti, Lourd Matha School and Vinobaji Nagar, all other samples for O.W were found to be within the limit. The flouride, sulphate and phosphate concentrations were found to be satisfactory in all the water samples analysed.

### Comparison of water quality parameters before and after the launching of SBA

A comparative study was carried out to assess the SBA programme in Dindigul corporation limit (**Table 9**). The results obtained in the present study are compared with the previous study conducted by Mohammed Hanipha et al[16]. Parameters such as pH, TDS, EC, TH,  $Cl^-$  and  $NO_3^-$  concentration were compared with respect to ten sample sites. It was found that values of all other parameters except chloride concentration was decreased which shows quality of water slowly approaching BIS limit. This also signifies the effort taken by the corporation authorities in handling the water quality parameters with the help of SBA. But increase in the amount of chloride concentration is not appreciable and which may be due to the discharge of tannery waste water containing high chloride content. Tanneries form the major industrial operation in the study area.

### 3.3 Bacteriological analysis

Biological studies have been conducted in open well samples. According to Indian Standards; E-Coli shall not be detected in 100mL/sample of potable water. **Table 6** shows that sample numbers 4, 7, 8, 9, 11 and 12 are critically contaminated with E-Coli and sample 10 is highly contaminated. Sample 2, 3 and 5 are also contaminated.

### 3.4 Soil analysis

Soil samples from an open defecation field frequently contains eggs of parasites and animals, such as rats, domestic animals like pigs and dogs as well as that of birds. Human parasitic helminth eggs can be accurately identified using an eyepiece micrometer in a microscope. In the present study soil isolates from 101 to 111 show a number of eggs of human parasitic helminths most frequently found in defecated soil samples. The predominant Helminth eggs present in the sample analysed were infertile *Ascaris lumbricoides* eggs and fertile *Ascaris lumbricoides*. Out of the eleven samples analysed, two samples (101 & 107) required the presence of *Trichuris trichiura* (whipworm) eggs. Sample numbers 102, 109 & 110 did not show microbial content (**Table 7**). It was noted that most of the Helminth affected soils are in slum areas nearby ponds. Sample number 11 (Gopalamudram) was previously an O.D area where people used water from two open wells

inside Gopalamudram. From **tables 6&7**, it is clear that both soil and water are contaminated. It can be observed that quality of soil and quality of water are inter related.

### CONCLUSION

The study assessed the physico-chemical parameter of water samples from hand pump, mini power pump, dam water and ground water in and around Dindigul Corporation limit. Twenty two important parameters like appearance, colour, odour, turbidity, electrical conductivity, pH, pHalkalinity, total hardness, calcium, magnesium, iron, manganese, ammonia, nitrite, nitrate, chloride, fluoride, sulphate, phosphate, oxygen were analysed. Related parameters like TDS, EC and Total hardness were found to be above the level of Indian standard limit, whereas, other parameters are within the permissible limit in the case of hand pump, mini pump and dam water. With respect to open well water samples there is not much improvement in biological quality, but regarding physico-chemical parameters, they are within the permissible limit. Most of the soil samples were contaminated with fertile and infertile *Ascaris lumbricoides* eggs. Two samples [101 & 107] were found to have *Trichuris trichiura* (whipworm) eggs (**Figure 3**) and samples 110, 102, 109 did not show microbial contaminants. When the quality of water in the study area are compared with previous studies carried out prior to the launching of SBA, there is an improvement in the quality. The effort taken by Dindigul Corporation in executing Swachh Bharat Abhiyan is appreciable but more initiatives are needed in maintaining the quality of water and soil. Swachh Bharat Abhiyan has made a positive impact in the society.

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#### Figures

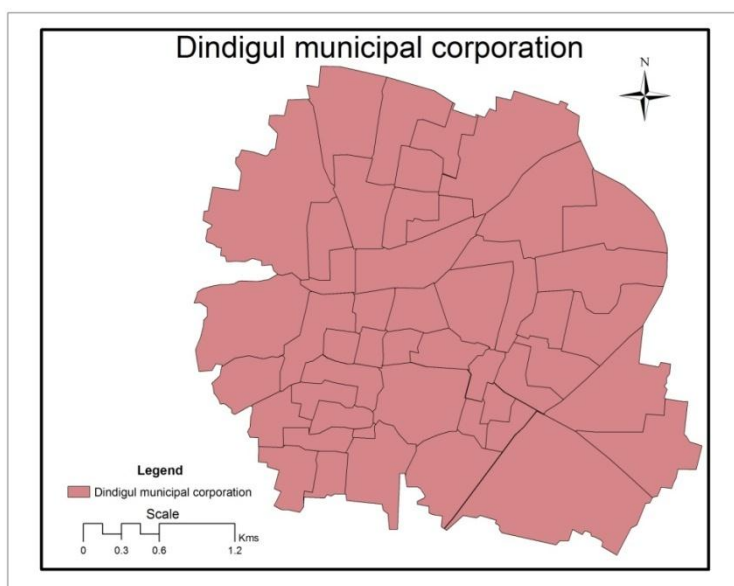
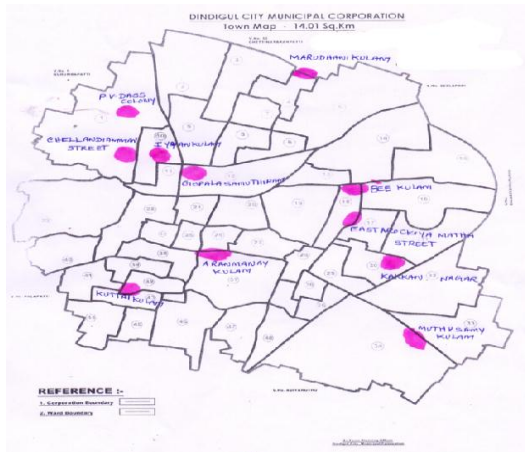


Fig. 1: GIS map of Dindigul Corporation

**OD spots identified**



**OD spots converted**



Fig.2: Map of open defecation spots identified and converted



Fig.3: Micrographs Of Ascaris lumbricoides (infertile & fertile) and Trichuris trichiura Conclusion Tables

Activities	2014-15	2015-16	2016-17	2017-18
House hold toilets	-	1840	1180	1180
Community toilets	-	4	2	-
Public toilets and urinals	-	-	-	-
Solid waste management	-	17	-	-
ODF	-	-	44 wards	48 wards
Construction of CT&PT	-	42	12	6
Solid waste management	1	2	3	3
Bio digesters	-	-	2	2

Table .1: Year wise analysis of activities of Swachh Bharat Abhiyan in Dindigul Corporation

PHYSICAL EXAMINATION:	BIS Limit: (10500: 2012)		Lab No																				
	Acceptable limit	Permissible limit in the absence of alternative source	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1. Appearance	-	-	Turbid	Clear & Colourless								Turbid	Clear & Colourless	Turbid	Turbid	Clear & Colourless	Clear & Colourless	Turbid					
2. Colour (pt.co-scale)	5	15																					
3. Odour	Unobjectionable		Slightly foul																				
4. Turbidity NT Units	1	5	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	0	0	3	0	0	
5. Total diss. Solids mg/l	500	2000	1890	770	1330	1400	<b>2310</b>	1680	560	210	1050	1190	1470	1400	840	1120	1750	1260	1680	2100	1120	1190	
6. Electrical Conductivity Micro mho/cm	-	-	2700	1100	1900	2000	3300	2400	800	300	1500	1700	2100	2000	1200	1600	2500	1800	2400	3000	1600	1700	
II. CHEMICAL EXAMINATION:																							
7. pH	6.5-8.5	6.5-8.5	7.90	8.20	8.20	8.20	7.50	8.10	8.10	8.10	8.30	8.10	8.10	7.70	7.90	8.20	8.10	8.30	7.90	8.2	8.1	8.2	
8. Ph. Alkalinity as CaCO <sub>3</sub>	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9. Total Alk. as CaCO <sub>3</sub>	200	600	480	240	400	380	460	420	200	30	340	380	420	400	240	360	480	400	460	520	420	440	
10. Total Hardness as CaCO <sub>3</sub>	200	600	<b>700</b>	300	460	500	<b>800</b>	<b>680</b>	260	60	400	440	520	480	300	420	<b>660</b>	460	<b>650</b>	740	480	500	
11. Calcium as Ca	75	200	175	75	115	125	200	170	65	15	100	110	130	120	75	105	165	115	163	185	120	125	
12. Magnesium as Mg	30	100	67	29	44	48	77	65	25	6	38	42	50	46	29	40	63	44	63	71	46	48	
13. Iron as Fe	0.1	1.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0.0	0.0	0.0	0	0	0	
14 Manganese	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
15. Free Ammonia as NH <sub>3</sub>	0.5	0.5	0.1	0.3	0.3	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.3	0.2	0.4	0.2	0.3	0.2	0.3	0.3	0.3	0.2	
16. Nitrite as NO <sub>2</sub>	0.5	0.5	0.0	0.2	0.2	0.2	0.2	0.3	0.3	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
17. Nitrate as NO <sub>3</sub>	45	45	21	10	14	22	32	22	10	2	11	14	17	18	3	12	18	15	21	29	13	16	
18. Chloride as Cl	250	1000	460	180	360	380	<b>620</b>	520	90	80	260	300	400	380	<b>250</b>	260	540	320	390	540	220	240	
19. Fluoride as F	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1	1	1	
20. Sulphate as SO <sub>4</sub>	200	400	79	23	52	31	87	62	12	5	32	39	62	55	10	48	69	45	62	91	35	42	
21. Phosphate as PO <sub>4</sub>	0.5	0.5	0.0	0.3	0.3	0.4	0.4	0.2	0.3	0.1	0.2	0.3	0.2	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.2	
22. Tidys Test 4 hrs.as O <sub>2</sub>	-	-	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	

Table.2: Physico Chemical analysis of Hand pumps and Mini power pumps

I.PHYSICAL EXAMINATION:	BIS Limit: (10500: 2012)		Lab No																
	1	2	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1. Appearance	-	-	Turbid	Clear & Colourless							Slightly foul							Turbid	
2. Colour (pt.co-scale)	5	15																	
3. Odour	Unobjectionable		Slightly foul																
4. Turbidity NT Units	1	5	4	0	0	0	0	0	0	2	0	0	4	2	2	0	3	3	2
5. Total diss. Solids mg/l	500	2000	2240	2520	700	2450	1260	2170	2380	1400	1750	1890	3080	2100	4830	2030	2100	1540	1470
6. Electrical Conductivity Micro mho/cm	-	-	3200	3600	1000	3500	1800	3100	3400	2000	2500	2700	4400	3000	6900	2900	3000	2200	2100
II.CHEMICAL EXAMINATION:																			
7. pH	6.5-8.5	6.5-8.5	7.70	7.80	8.20	7.60	7.60	8.20	7.80	8.10	7.80	7.90	7.80	7.80	7.70	8.10	8.10	7.40	7.70
8. Ph. Alkalinity as CaCO <sub>3</sub>	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. Total Alk. as CaCO <sub>3</sub>	200	600	480	240	400	380	460	420	200	30	340	380	420	400	240	360	480	400	460
10. Total Hardness as CaCO <sub>3</sub>	200	600	760	840	260	820	300	700	820	460	680	700	820	680	1180	740	780	640	640
11. Calcium as Ca	75	200	190	210	65	205	75	175	205	115	170	175	205	170	295	185	195	160	160
12. Magnesium as Mg	30	100	73	81	25	79	29	67	79	44	65	67	79	65	113	71	75	62	62
13. Iron as Fe	0.1	1.0	0.3	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0.2	0.2	0.
14. Manganese	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. Free Ammonia as NH <sub>3</sub>	0.5	0.5	0.4	0.3	0.3	0.4	0.2	0.3	0.4	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.4
16. Nitrite as NO <sub>2</sub>	0.5	0.5	0.2	0.3	0.2	0.3	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.4	0.2	0.3	0.2	0.2	0.2
17. Nitrate as NO <sub>3</sub>	45	45	21	27	7	26	14	28	32	14	18	22	30	26	38	25	22	18	15
18. Chloride as Cl	250	1000	620	700	180	660	460	600	600	400	380	450	1100	600	1860	480	480	300	280
19. Fluoride as F	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
20. Sulphate as SO <sub>4</sub>	200	400	95	115	21	116	65	118	132	62	85	92	128	112	132	112	127	67	5
21. Phosphate as PO <sub>4</sub>	0.5	0.5	0.3	0.2	0.3	0.4	0.2	0.3	0.4	0.3	0.3	0.2	0.4	0.2	0.4	0.4	0.3	0.3	0.4
22. Tidys Test 4 hrs.as O <sub>2</sub>	-	-	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table.3: Physico-Chemical analysis of Hand pumps and Mini power pumps



I.PHYSICAL EXAMINATION:	BIS Limit: (10500: 2012)		Lab No											
	Acceptable limit	Permissible limit in the absence of alternative source	1	2	3	4	5	6	7	8	9	10	11	12
1. Appearance	-	-	clear	Clear & Colourless						Turbid	Turbid		Turbid	Turbid
2. Colour (pt.co-scale)	5	15												
3. Odour	Unobjectionable		Slightly foul											
4. Turbidity NT Units	1	5	0	0	0	0	0	0	0	4	2	3	2	2
5. Total diss. Solids mg/l	500	2000	1540	1750	1372	1680	3080	5040	3220	2030	1470	1050	1260	2450
6. Electrical Conductivity Micro mho/cm	-	-	2200	2500	1960	2400	4400	7200	4600	2900	2100	1500	1800	3500
II.CHEMICAL EXAMINATION:														
7. pH	6.5-8.5	6.5-8.5	7.94	8.00	8.30	8.10	8.30	7.70	7.50	6.90	7.90	7.95	8.00	8.00
8. Ph. Alkalinity as CaCO <sub>3</sub>	-	-	0	0	0	0	0	0	0	0	0	0	0	0
9. Total Alk. as CaCO <sub>3</sub>	200	600	400	550	580	430	480	350	550	350	500	400	440	500
10. Total Hardness as CaCO <sub>3</sub>	200	600	600	700	460	520	780	1800	840	780	580	460	500	860
11. Calcium as Ca	75	200	150	175	115	130	195	450	210	195	145	115	125	215
12. Magnesium as Mg	30	100	58	67	44	50	75	173	81	75	56	44	48	83
13. Iron as Fe	0.1	1.0	0.3	0	0	0	0	0	0	0.2	0.1	0.2	0.1	0.1
14. Manganese	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0
15. Free Ammonia as NH <sub>3</sub>	0.5	0.5	0.2	0.3	0.3	0.4	0.4	0.5	0.4	0.3	0.2	0.2	0.3	0.4
16. Nitrite as NO <sub>2</sub>	0.5	0.5	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.2
17. Nitrate as NO <sub>3</sub>	45	45	18	21	13	22	34	38	36	27	18	12	15	32
18. Chloride as Cl	250	1000	360	380	300	520	1120	1280	1150	480	340	200	280	620
19. Fluoride as F	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
20. Sulphate as SO <sub>4</sub>	200	400	49	65	35	57	118	245	122	68	52	37	45	121
21. Phosphate as PO <sub>4</sub>	0.5	0.5	0.2	0.3	0.3	0.4	0.4	0.5	0.4	0.3	0.1	0.3	0.3	0.4
22. Tidy's Test 4 hrs. as O <sub>2</sub>	-	-	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.9

Table.4: Physico-Chemical analysis of Open well water

I.PHYSICAL EXAMINATION:	BIS Limit: (10500: 2012)		Lab No			
	Acceptable limit	Permissible limit in the absence of alternative source	1	2	3	4
1. Appearance	-	-	clear			
2. Colour (pt.co-scale)	5	15				
3. Odour	Unobjectionable					
4. Turbidity NT Units	1	5	4	1	0	0
5. Total diss. Solids mg/l	500	2000	329	266	595	623
6. Electrical Conductivity Micro mho/cm	-	-	470	380	850	890
<b>II.CHEMICAL EXAMINATION:</b>						
7. pH	6.5-8.5	6.5-8.5	7.6	7.6	8.4	8.3
8. Ph. Alkalinity as CaCO <sub>3</sub>	-	-	0	0	0	0
9. Total Alk. as CaCO <sub>3</sub>	200	600	100	80	140	200
10. Total Hardness as CaCO <sub>3</sub>	200	600	160	140	200	260
11. Calcium as Ca	75	200	40	35	50	65
12. Magnesium as Mg	30	100	15	13	19	25
13. Iron as Fe	0.1	1.0	0.3	0	0	0
14 Manganese	0.1	0.3	0	0	0	0
15. Free Ammonia as NH <sub>3</sub>	0.5	0.5	0.4	0.3	0.2	0.2
16. Nitrite as NO <sub>2</sub>	0.5	0.5	0.2	0.2	0.2	0.1
17. Nitrate as NO <sub>3</sub>	45	45	2	1	4	6
18. Chloride as Cl	250	1000	50	40	120	150
19. Fluoride as F	1.0	1.5	0.8	0.8	0.8	0.8
20. Sulphate as SO <sub>4</sub>	200	400	5	4	13	19
21. Phosphate as PO <sub>4</sub>	0.5	0.5	0.4	0.2	0.1	0.1
22. Tidy Test 4 hrs.as O <sub>2</sub>	-	-	0.9	0.9	0.8	0.8

Table.5: Physico- Chemical analysis of Dam water

S. No	Sample	combination	MPN index per 100 ml	95% confidential limit	
				Lower	Upper
1	G01	3-2-3	290.00	90.0	1000.00
2	G02	3-1-0	43.00	9.00	180.00
3	G03	3-2-2	210.00	40.00	430.00
4	G04	3-3-2	1100.00	180.00	4100.00
5	G05	3-2-3	290.00	90.00	1000.00
6	G06	1-2-0	11.00	3.60	42.00
7	G07	3-3-3	>1100	420	-
8	G08	3-3-3	>1100	420	-
9	G09	3-3-3	>1100	420	-
10	G10	3-3-1	460	90	2000
11	G11	3-3-3	>1100	420	-
12	G12	3-3-3	>1100	420	-

Table 6. Bacteriological analysis of open well water

Sample code	pH	Type	Nematodes	Cestodes	Digestive Strongyles	A	N=AX/PV	Nematode Sp.	Remarks
101	6.7	Sand	+	-	-	2	1.33	Trichuris trichuria	Fertile
102	6.2	Lateritic	-	-	-	0	0	-	-
103	7.12	Dark alluvial	+	-	-	6	4	Ascaris lumbricodes	Fertile
104	7.2	Dark	+	-	-	3	2	Ascaris lumbricodes	Infertile
105	6.3	Sand with Algaeplugging	+	-	-	4	2.6	Ascaris lumbricodes	Infertile
106	7.2	Dark	+	-	-	2	1.33	Ascaris lumbricodes	Fertile
107	6.7	Sand	+	-	-	1	0.66	Trichuris trichuria	Fertile
108	7.12	Dark with Humus	+	-	-	6	4	Ascaris lumbricodes	Infertile
109	6.8	Dark	-	-	-	0	0	-	-
110	6.7	Lateritic	-	-	-	0	0	-	-
111	7.9	Dark	+	-	-	3	2	Ascaris lumbricodes	Fertile

Table.7: Helminth analysis of soil samples

Helminth	parameters	Round 1		Round 2	
		titled	consenses	titled	consenses
Trichuris	Sensitivity	96%	96%	94%	94%
	Specificity	93%	93%	93%	93%
	False positive rate	2%	2%	1%	1%
	False negative rate	1%	1%	1%	1%
	Efficiency	99%	99%	99%	99%
	Selectivity	-0.79%	-0.79%	-0.79	-0.79
Ascaris	Sensitivity	97%	97%	98	98%
	Specificity	94%	94%	93	94%
	False positive rate	10%	8%	10	10%
	False negative rate	7%	11%	7	12%
	Efficiency	89%	87%	89	85%
	Selectivity	-0.63%	-0.66%	-0.64	-0.62%

Table.8: Microscopic Evaluation of soil samples

Sample sites	Before launching of SBA						After launching of SBA					
	pH (6.5-8.5)	TDS (500-2000)	EC (-)	TH (200-600)	Cl <sup>-</sup> (250-1000)	NO <sub>3</sub> <sup>-</sup> (45)	pH (6.5-8.5)	TDS (500-2000)	EC (-)	TH (200-600)	Cl <sup>-</sup> (250-1000)	NO <sub>3</sub> <sup>-</sup> (45)
Paraipatti	7.5	1459	2518	471	366	28	7.5	1330	1900	460	520	22
Poochinayakanpatti	7.7	696	1082	654	263	28	7.7	595	850	200	1120	34
Bharatipuram	7.4	740	1139	902	746	20	7.4	710	1100	300	340	18
Nehruji nagar	7.5	1304	2145	386	288	17	7.5	1050	1500	400	540	18
R.R.Pudur	7.5	1201	1705	958	609	27	8.1	1190	1700	440	600	17
Koil street	7.9	1048	1406	733	363	23	8.2	700	1000	840	380	22
Burma colony	8.2	1719	2872	1768	1312	45	7.6	1260	1800	300	1100	27
Santhai road	7.7	928	1333	776	482	36	8.3	623	890	260	480	27
Malai koil	7.3	850	1253	706	315	21	8.2	770	1100	300	350	13
	8.1	273	382	248	61	37	7.6	266	380	140	400	14

Table 9 Comparison of physico chemical analysis of water samples before launching of Swachh Bharat Abhiyaan in Dindigul Corporation limit

S. No	Sample code	Name of place	Type of source
1	1	Ayyankulam	Mini Power Pump
2	2	Muthalakupatti	Mini Power Pump
3	3	R V Nagar	Mini Power Pump
4	4	Gandhi market	Mini Power Pump
5	5	Chinnayapuram	Mini Power Pump
6	6	Kavadakkaran street	Mini Power Pump
7	7	St.Xaviers street	Mini Power Pump
8	8	Bus stand	Mini Power Pump
9	9	Kakkan Nagar	Mini Power Pump
10	10	Daivasikhmanipuram	Mini Power Pump
11	11	Round road pudur	Mini Power Pump
12	12	Kumaran tiru nagar	Mini Power Pump
13	13	Opposite peekulam	Mini Power Pump
14	14	Post office junction	Mini Power Pump
15	15	Joseph colony	Mini Power Pump
16	16	Kalimuthupillai street	Mini Power Pump
17	17	Ramanathapuram east	Mini Power Pump
18	18	Maruthanikkulam	Mini Power Pump
19	19	Muthalakpatti	Hand Pump
20	20	R V Nagar	Hand pump
21	21	Narippara	Hand pump
22	22	Rajalakshmi nagar	Mini Power Pump
23	23	Near Soundaraja mill	Hand pump
24	24	Cremetorium near	Mini Power Pump
25	25	Nagal nagar	Mini Power Pump
26	26	J.J.Nagar	Mini Power Pump
27	27	Mottanampatti road	Mini Power Pump
28	28	Enamel factory road	Hand pump
29	29	Pettai road	Mini Power Pump
30	30	Natirsha street	Mini Power Pump
31	31	Savariyar palayam	Hand pump
32	32	RV Nagar	Mini Power Pump
33	33	Yusipiar nagar	Mini Power Pump
34	34	Muhammadiyahapuram	Mini Power Pump
35	35	Chinnayapuram	Hand pump
36	36	Chettinayakampatti road	Hand Pump
37	37	PV Das colony	Hand pump

Table 10 List of sample sites for MPP and HP

S. No	Sample Code	Name Of Place	Type Of Source
1	1	R.MColony	Open Well Water
2	2	Narayanpillathottam	Open Well Water
3	3	Kumaran Park	Open Well Water
4	4	Parappatti	Open Well Water
5	5	Poochinayakampatti	Open Well Water
6	6	Lurdmatha School	Open Well Water
7	7	Vinobaji Nagar	Open Well Water
8	8	Nagal Nagar	Open Well Water
9	9	Bharathi Hostel	Open Well Water
10	10	Venkateswara Water Agency	Open Well Water
11	11	M.S.P.School	Open Well Water
12	12	Gopalamudram	Open Well Water

Table 11 List of sample sites for open well water

S. No	Sample Code	Name Of Place	Type Of Source
1	1	Athur Dam starting point	Dam Water
2	2	Athur Dam end point	Dam Water
3	3	Kaveri Dam starting point	Dam Water
4	4	Kaveri Dam end point	Dam Water

Table 12 List of sample sites for dam water

S. No	Sample Code	Name of Place
1	101	Maruthanikkulam
2	102	P.V.Das colony
3	103	Chellandiamman street
4	104	Ayyankulam
5	105	Kuttaikkulam
6	106	Aramanakulam
7	107	Muthuchamikulam
8	108	Kakkan Nagar
9	109	East Arogyamatha street
10	110	peekulam
11	111	Gopalamudram

Table 13. List of sample sites for soil analysis