A longitudinal bacteriological study of drinking water quality in rural Western Maharashtra and its effects on changes in local drinking water management and practices.

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ABSTRACT

A longitudinal study was undertaken with aim of testing bacteriological quality of rural water supplies. A continuous feedback to the community was undertaken aiming a movement towards self-help against diseases like diarrhoea and improved water management through increased community participation. Total 313 water samples were collected from piped supply and alternate sources from 6 villages. Hundred and fifty six (49.8%) samples were polluted. From the piped water supply, 91(45.9%) samples were polluted. Overall ground water quality was good as compared to open wells. Irregular and / or inadequate treatment of water, lack of drainage systems, domestic washing near the wells lead to deterioration in water quality. No major diarrhoeal epidemics were recorded during the study although a few sporadic cases were

noted during rainy season. Peoples' perceptions changed with time and increased awareness noted through active participation of people cutting across age groups and different socio-economic strata of the society in the village activities. Thus, drawing attention towards water supply and management at community level served to inculcate a problem solving capacity for water related issues in a chronic drought prone rural community.

KEY WORDS

Community participation; Drinking water quality; Piped water schemes; Seasonal variations.

INTRODUCTION

Water scarcity and pollution both microbial and chemical are major problems faced by the rural population in several parts of India. (Govt. of Maharashtra 2004; World Bank 1998; The Hindu 2004) Whilst deaths due to infectious diarrhoea and related causes are measurable at 1.8 million per year (WHO 2004), the toll taken by chemical pollution remains unmeasured and little understood (The World Bank 1998). Repeated annual droughts in the last decade due to failed monsoons and widespread deforestation have created situations of chronic water scarcity in areas which had hitherto received abundant rainfall. Whilst urban industrial centers in such areas continue to receive water supplies from rural lakes and water sources by virtue of their economic status, rural communities with no traditional base of water harvesting and conservation are left in the lap of migration and / or destitution. Relief in such times comes in the form of water tankers, fodder camps for cattle - which at best may be palliative but which also threaten to turn water into a saleable commodity. Voluntary organizations experienced in water harvesting technologies and conservation have been late entrants but implementation of these technologies requiring the viewing of water as a community resource is a hard message to accept in difficult times. Lack of sanitation has a detrimental effect on water potability concentrating diarrheagenic organisms in the small residues of water in wells, lakes etc. Piped water schemes for supplying water from reservoirs are often prey to faults in sanitary engineering, extended interruptions in electricity and lack of community ownership due to its erratic performance (Chaudhari et al. 2000).

The Parinche valley in Purandar block of interior Western Maharashtra is one such area where the abovementioned conditions have prevailed. With a population of 20,000 scattered in 40 villages, the valley can be dissected into 3 geographical regions extending from gently indulating agriculture land on the eastern side to western mountainous margin of an altitude of 7000 ft. The rainfall is binomially divided into 80-100 inches a year on the western side of the valley, with the eastern side receiving annually and average of 28 inches. In the last four years the average has receded to 41.2 inches and 10.3 inches respectively. Though receiving abundant rain, the western side of the valley is poorer economically and has had no water conservation activity up to the termination of the study period.

The study extended for a period of approximately one year from September 2000 – September 2001. The approach in this study was grounded in the belief that amelioration of the above situation resets with the efforts of the local community. Given the iniquitous water distribution and lack of community control of this vital natural resource, the understanding of issues related to both water quality and quantity becomes necessary. Since institutional expertise was readily available to test and influence water quality, the primary approach to consolidate community focus was restricted to water quality in bacteriological terms due to its connection with water borne diseases. The concurrent linkage of village events to water quality and availability, peoples' perceptions and feedback to the population was an intrinsic part of the present approach. Transfer of technological knowledge and its use for social advocacy were the expected outputs of this approach.

A catalytic presence of women health and development workers in the valley, trained for a decade by the Foundation for Research in Community Health (FRCH, a non-governmental association) in preventive, promotive and curative health, facilitated the abovementioned approach (Antia et al. 2004). Sustained interaction with the community dictated that the bacteriological evaluation of water quality be undertaken on a longitudinal bases. This had an additional advantage in studying the seasonal variation in water potability and tackling of specific seasonal problems. The delving into bacteriology was gauged to have a better effect if the observations were made closer to each home in the community. Hence a three-tiered longitudinal survey was planned from the wells and tanks to stand post, taps and eventually the stored household supplies.

METHODS

Background including community features, water related practices and concurrent interventions

Situated 60 kms. South from the city of Pune, the project area was divided into 3 major valleys of Parinche, Pangare and Kaldari designated for ease as areas A, B and C respectively. Six villages, from area A (Parinche, Shindewadi), area B (New Hargude, Kambalwadi) area C (Kharadwadi, Kondkewadi) were selected on the basis of area, geological position, frequency of water supply, number and presence of common as well as private tap connections and recorded recent epidemics of diarrhoeal diseases.

Trained staff members and health functionaries from The Foundation For Research in Community Health (FRCH), based in Pune gathered the detailed information for the study listed in Table1 through several meetings with the community, visiting local governing bodies (Gram Panchayat) for the information about the population etc. Various modes of community interaction also included regular meetings in the villages, interviewing the selected families for the household water testing, bringing out a bimonthly poster newsletter called “Maitri” (friendship) covering various health related issues, regular notice-board writing including the topics such as water purification, water management, animal diseases and care, useful information about crops, socio-cultural events in the village, functions of Gram Panchayat etc.

In order to achieve a rapid spread of the information and to get a better participation of the local people, an "Eco (ecological) group" comprising of the school children in each village was formed**.** It was thought that if informed and trained in several environmental issues and simple techniques including drinking water that had a direct effect on their day to day lives, school children could help in increasing awareness among their families and thus in the entire community in a shorter time span. They could also mediate between the FRCH staff members and their families resulting in an increased and in depth community contact. These children were trained in collection of water samples from various types of sources, determining drinking water quality by MPN method, methods of water purification like chlorination, preparation of a “mother solution” (a derivative of chlorine) used for treatment of water at the household level, estimate the storing capacity of a sources such as wells and tanks, estimate the chlorine requirement for adequately treating these sources, detection of residual chlorine using Orthotoluedine as an indicator along with other environmental topics of water conservation and water recycling, identifying and sampling the local antidiarrhoeal plants.

The regular water supply cycles in all the villages were studied in depth along with the water storing practices at the household level. The study began with the objectives of assessing the quality of all water sources including the piped water supplies along with the alternate sources some of which were used for drinking as well as for agriculture and domestic washing, informing and discussing with the community about local water quality, evolving solutions and creating awareness. We also aimed at effecting changes in the perceptions and water storing practices by people after learning about the health implications of contaminated water. In addition, studying the effect of seasonal variation on the water sources was attempted through the longitudinal approach.

Water supply, management and treatment

In all the villages, from the onset, water was pumped into the tank from a well and further supplied through pipelines. Its availability mainly depended on the water levels in the main wells. A person was appointed by the Gram Panchayat in each village to provide TCL (Total Chlorides of Lime) as in bleaching powder, [$Ca(OCl)_2$] chlorinating the well / tank water and for the maintenance of the pumping systems. The TCL powder was normally available at the Gram Panchayat office.

The study area being situated on a hard rock, the depth of wells in these villages could not be increased beyond an extent. Hence, arrangements such as supplying water from a nearby dam or percolation through bundings as well as percolation tanks was attempted to increase the levels of well water. Chlorination treatment was irregular and / or inadequate with regular electricity failures; drainage systems were not properly developed except in Parinche (area A), where maintenance was poor.

Of the 18 families chosen from 6 villages, a majority (13; 72.2%) comprised of an open caste category (mainly Maratha and Mahadev Koli). Four (22.2%) belonged to backward class and 1 (5.6%) was from other backward class catagory. Majority (16; 88.9%) of the family heads had completed their secondary school education. Agriculture was the main occupation recorded.

At the household level, people stored the drinking water largely in stainless steel or brass vessels and least in copper vessels. The vessels were covered and the surrounding area was clean and dry. People followed the traditional practice of washing hands after returning home. However, withdrawal of drinking water without a ladle could lead to its contamination. People treated the water only if it looked turbid / muddy or in the rainy season. Most families kept the animals near or inside the houses as only a few people could afford seperate animal sheds.

The alternate sources were categorized into two groups based on their use: group 1, the sources which were used for drinking water in case of water shortage and group 2, sources mainly used for agriculture, domestic washing and animals. However, there was a possibility that people could use these group 2 sources for drinking water when working in fields. In the absence of the piped water, people filled water directly from the main well. Hence, use of alternate well water for drinking was minimal and was restricted to domestic work, animal consumption and agriculture.

Group 1 sources included total 4 hand pumps from area A, B and 4 wells from area A and C. Group 2 sources were total 7 wells, 3 each in area A, B and 1 in area C along with a percolation lake and a natural stream from area C. No treatment was given to any of these sources throughout the year. Washing of utensils, cloths or domestic animals was done near these sources. Drainage conditions surrounding these sources were poor. Few of these wells were equipped with electricity or diesel pumps for agricultural water; however, water collection for domestic purposes was done using a vessel from an individual household. All these factors were thought to cause external contamination of the water bodies.

Scarcity of water and probable pollution of water was found to be the major problem in all the villages. A passive attitude was observed towards the available water supply in the village and ignorance about its quality. In our efforts therefore, we tried to inculcate self-help measures by people for both management of the available water sources of water and their quality. We anticipated an active participation of people in improvement in the water supply schemes in their villages, tackling the local problems viz. leakages, poor drainage conditions, increased demand for regular chlorination of water and keep a check over the entire functioning of the schemes.

As for the endpoint users, use of simple methods for quality maintenance such as use of a ladle, fitting the taps to their collection vessels to minimize contamination through hands, disinfection methods use of copper vessels / wires, mother solutions were advocated that were studied earlier at the Foundation for Medical Research (Mistry et al. 2003). An acceptance and utilization of these measures was anticipated at the end of the study.

Bacteriological Testing

The trained staff members of the FRCH at the field collected samples. One sample from each village was collected at random and tested for potability. During the first three months of random testing, a few samples were found polluted. It was decided to test the samples from all the sources i.e. wells, tanks and the taps simultaneously to detect at which level the pollution was occurring. In addition, it was thought necessary to also test the alternate sources that were used for drinking water in case of water scarcity.

The period of one year was roughly divided into 4 seasons. Spring (January, February, March); Summer (April, May and June); Rainy season (July, August, September) and Winter (October, November and December). Initially the sampling was done once in each season. However, the frequency of sampling was increased from one to two in a season.

Sample collection and transport

All testing was performed at the Foundation for Medical Research (FMR), an established and well-reputed research organization approximately 220 kms away from the point of collection. The samples were collected in 500 ml sterile plastic bottles containing 18 mg / lit sodium thiosulphate solution for treated samples (Cheesbrough 1998). All necessary precautions were taken to avoid probable external contamination during sample collection. Sample details were recorded in a questionnaire. All the samples were tested for the residual chlorine content with a commercially available chlorine testing kit with orthotoludine (OT) (Aquamerk). The treatment status of the samples was determined on the basis of the above test results. The samples were maintained at $15^{O}C \pm 5^{O}C$ and transported within 24 hours to the laboratory.

Most Probable Number (MPN) technique

The samples were tested for the presence of the coliforms by the Most Probable Number (MPN) technique (Cheesbrough 1998). Samples with 0 coliforms per 100 ml of original water were taken as excellent, with 1-10 coliforms as acceptable and above 10 coliforms as polluted (Bureau of Indian Standards 1995).

Bacterial culture

Besides the MPN test, 50 ml of each sample was centrifuged in a sterile plastic centrifuge tube at a speed of 2000 rpm for 10 minutes under cold conditions ($15^{O}C \pm 5^{O}C$). The pelletes were then streaked onto sterile MacConkey agar, and sterile Brain Heart Infusion (BHI) agar plates incubated at $37^{o}C$ / 18-24 hours followed by propagation into BHI broth and identification by standard biochemical testing (Kreig et al. 1986; McFaddin 1980a, b, c; Sneath et al. 1986).

Statistical analysis was undertaken using a one tailed χ^2 test wherever appropriate.

RESULTS

Main sources

Wells : Out of the total 32 samples collected, only 7 (21.9 %) were treated. Five of these (71.4 %) were acceptable. Fifteen of the remaining 25 untreated samples (60.0 %) were polluted. However, a considerable number of samples (11; 34.4 %) were found to be excellent / acceptable. A major proportion of such cases were observed in area B, (Kharadwadi 6 cases, Kondkewadi 4 cases). The probable reason was that while the residual chlorine treatment of the previous day could not be detected, its sanitizing effect was manifested.

Tanks : There were many problems hindering the availability of tank water. Several technical reasons were associated with water shortages faced by the community (Table 2).

Overall 19 tank water samples were studied from the 6 study villages throughout the year. Of these, seven of the 8 treated samples (87.5%) were excellent. Among the 11 untreated samples 7(63.6%) were found to be polluted. The overall tank water status is depicted in the Figs 1-6. Except area A (Parinche) where regular treatment was observed, a majority of the samples were polluted. A regular cleaning of the tank in area C (Kharadwadi) resulted in consistently acceptable water quality.

Stand posts : Twelve random samples were collected initially. Later, one common stand post from each village was selected. Thus, a total of 31 tap water samples were tested**.** Of the 31 samples, 12 samples were treated. Nine of these (75.0%) were found acceptable, The remaining 19 samples were untreated of which 10 (52.6%) were polluted and 9 samples (47.4%) were within acceptable limits.

Nineteen tap water samples were tested concurrently with the main source (Fig 1-6). All samples supplied from a treated source (8; 100%) were found to be acceptable. Among the remaining 11 samples that were untreated, only 4(36.4%) were polluted. Seven (63.6%) were acceptable. Acceptable tank water quality could be the reason in one of the village from area C (Kharadwadi), however observations in the other village from the area (Kondkewadi) were difficult to explain.

It was noticed that whenever clean tank water was supplied, the tap water was found to be acceptable (10/18; 55.6%). On 4 occasions both tank and tap water were polluted. ($P < 0.001$) In the remaining 4 cases comparisons could not be made due to inability to collect from one of the sources. Overall the engineering aspect of laying of pipelines from tanks to stand post was satisfactory.

Household samples : In all, 115 household samples were studied. Figs 1-6 depicts the quality of water from the selected families. Thirty-four samples in all were treated, of which, 25 (73.5%) were acceptable. Of the remaining 81 samples, 43 (53.1%) were polluted whilst a considerable 38 samples (46.9%) were found to be acceptable. Probably mixing the old stock of water containing residual chlorine with the fresh stock could have lead to disinfection to some extent. No difference was found in the quality of water from the backward class families and the other families in both cases when provided water was clean ($0.1<P<0.2$) or unclean ($0.3<P<0.5$)

When water supply was clean : Overall, 13 / 115 (11.3%) households were supplied with clean water demonstrated pollution when household water supplies were tested. A greater proportion of this was in the villages of area C (Kharadwadi 4 cases, Kondkewadi 5 cases). All the 6 households from these villages were found to be polluted in early June probably because lack of water resulted in the extended use of the old stock and thus increased handling of the stored water.

When supplied water was polluted : On the other hand, there were cases where the water at the household level was clean despite a polluted water supply. A total of 13 / 115 (11.3%) such samples were found throughout the study. One sample from area A (Parinche) was suspected to be a previous day stock, which probably was treated. Three of the households had treated the water at a household level with "mother solution”. Use of mother solution was more frequent in the latter part of the study especially in the houses of the children who were members of local ecological groups. In Kharadwadi (area C), in September, a small coliform count of 35 at the tap level reduced down to the acceptable level at the household level.

The quality of household water samples in relation to the source is depicted comprehensively in Table 4. Samples collected from different sources as well as those stored on the previous day were excluded from the table as also samples that could not be collected concurrently with tank on the same day. It is revealed that in all the three areas, a large proportion of household samples reflected the quality of source itself (1 and 2 in Table 4). Approximately 32 % of households in area A proved to have clean drinking water despite the source being contaminated. This reflects good management of household water. On the other hand, polluted household samples from area C despite the clean source signified the need for more attention towards health education required in the area. No leakages and thus seepage of drainage water was indicated by the results. The predominantly poor quality of the samples from the source level (26.3% in area A and 35.3% in area B) highlighted the default of the watermen hired by the Panchayats to adequately chlorinate the sources.

Alternate sources

Group 1 sources : Hand pumps : All the 21 hand pump samples (100.0%) were found to be acceptable. However, a sample in Area A, although within the acceptable limits, showed the presence of coliforms due to the contamination brought on during recent repairs. Of the 8 household samples collected from hand pumps, 7 were acceptable. Ground water level reduced in the summer season due to which the hand pump in area B (New Hargude) became non-functional and thus could not be sampled.

Wells : All 4 wells, 3 from area B and 1 from area C were used for drinking water in summer. All the 4 samples were untreated and found to be polluted. In area B wells were found to be polluted and so were the household samples that utilized the well water.

Group 2 sources : Among the 72 samples collected from the group 2 alternate sources, 50(69.4%) were polluted. 20(27.8%) were within the acceptable limits whereas only 2 samples (2.8%) were excellent (Table 3).

Overall, the ground water quality was found to be satisfactory which was indicated by the status of the hand pump water. However, all the open wells in the area were polluted.

There was no seasonal difference observed in the detection level of other heterotrophic bacteria (bacteria that require organic carbon for growth) by culture (Data not shown).

Observations in the community

The results of the bacteriological testing were informed to the people and appropriate solutions to the problems were discussed from time to time through periodic meetings during the study period. Diverse responses were received from all villages. Initially, watermen in some villages objected to the declaration of bacteriology results on the notice board. People in Parinche (area A) tried to shirk the responsibility of regular check up of water treatment saying that it was purely a waterman's job and they could not interfere. Nevertheless, they were willing to follow all precautions at the household level. In New Hargude from area B, availability of water was of greater concern than the quality of water and people felt that the quality of water was good enough and did not need any extra attention. Among the area C villages, Kharadwadi people were active and had carried out cleaning of the tank fairly regularly probably due to an active "eco" committee in the village. The observation made by eco group children during training were recorded, however, they are not included in the present study. In Kondkewadi (areaC) however, there was not much active response by the people.

This scenario however changed through continuous interaction with the people. Regular writing on the notice-boards, display of simple charts at the meetings that helped in spread of the messages of water-borne diseases, hygienic water storage and behavioural practices among the community. A positive action was observed towards tackling the problem of water availability in the villages (Box 1). These and several such incidents showed an increased awareness among the community about their rights for adequate and clean water supply and the ability to discuss these issues in meetings despite local political influence. On occasions, the politicians were even questioned for their poor performance. People also took the initiative to cooperate with the watermen in cleaning and maintaining the tanks. Improvement in cleaning and chlorination of water sources indicated an increased awareness about the quality of available water. Also, comments like "We learnt a lot during this process of water testing" indicated an increased awareness in and a positive response from the community.

At the household level, the families, which were included in the study, voiced some problems. Availability of water was the main, followed by casual handling of water by children. In response, some simple interventions were suggested. At the end of the study period, people had begun storing the water at a higher level. A comparative acceptance of the proposed interventions is shown in table 5. A copper wire of diameter 1 mm and surface area of 8 cm^2 was found to be bactericidal to *E.coli* after the duration of 8 hours in one litre of water when tested in the laboratory (Data not shown). Large copper vessels that were normally used for religious rituals are now being used routinely for water storage in area A. In area C, use of copper wires was preferred (Mistry et al. 2003) since use of mother solution was limited, particularly in the isolated villages in area C. This was due to inavailability of bleaching powder or lack of time and efforts to prepare the solution. Fixing a tap however, was also a costly alternative (approximately 1.5 US $ / fitting) , for the people in area C. This number however, is gradually increasing.

DISCUSSION

Rural India, despite five decades of planned development, continues to suffer multiple problems of access. Its primary needs of potable water, sanitation, health care, remain largely unmet. Between 1991-1998, the Government of Maharashtra launched two rural potable water supply and sanitation related projects in the state. The inclusion of " health education activities" was a unique component of both projects. About Pound Sterling 16 million and Rupees 600 crores were funded by Department for International Development (DFID) and World Bank (WB) respectively. A majority of the water samples tested (up to 100% in the area funded by both DFID and WB) at all levels viz. tanks, stand posts and households were found polluted. The distance of water reservoirs from the supply area lead to an increased operational cost of the schemes. Several engineering faults were also prominent in the systems. Meager acceptance of the health messages and reluctance to pay due taxes for supplied water resulted in an inefficient functioning of these schemes. Local watershed management with greater community participation and emphasis on self reliance could have resulted in better utilization of these funds. Social, political, economic as well as environmental factors are not conducive to discernible and successful development. A fundamental attitudinal change was indicated at political, administrative and societal levels to bring about sustained change. (Choudhari et al. 2000) The current study based on this principle was undertaken in such 6 representative villages that served as their own internal controls. Although all these villages were covered under the piped water supply, benefits accrued were limited. Lack of water was one of the major problems noticed. The entire system depended largely on the rainfall in the area for each year. The water level in the wells reduced in the summer season that led to partial failure of the piped water supply in some villages. In addition, a few technical problems (Table 2) resulted in interruptions to water supply.

The study through the socio-bacteriological approach previously desvribed became instrumental in focussing on several key points including the local governance of water supply schemes. Information about the poor status of water being provided and their rights for provision of clean water through the interaction with the health functionaries, stimulated people to take up the issue of improper management of the sources by the watermen to the authorities. The initial ignorance perceived in the process turned into a more fervent participation by the community.

The study also resulted in a propagation of simple interventions to maintain the water quality at the household level and their sustained acceptance by the community although its extent varied in the three areas as mentioned in the previous section.

Training of the eco group children lead to proximity of the community to simple technical aid in areas of water management and quality testing which otherwise was hitherto inaccessible. With the initiation of the study, an access for regular water testing at the FMR was availed which was explored by the community from time to time. This resulted in an overall feeling of self-reliance in the community. People expressed their concern to the public health officials when the functioning of the government bodies was found poor and a frequent discordance between the water testing results between the public health laboratory and our laboratory was observed (Data not shown).

Of the 313 samples collected, 156(49.8%) samples were polluted. From the piped water supply, 91(45.9%) were polluted when supplied. This suggested that the quality of water at source was not maintained up to the standards for drinking water laid by the Bureau of Indian Standards. Status of the pipelines in the above villages however, was satisfactory. Availability of water and its visible clarity was the prime concern to people than microbial quality. In addition, since no major diarrhoeal outbreaks were observed in the area, people perceived that they had developed immunity against such diseases. Hence, irregular / no chlorination was a common feature. Watermen appointed did not seem to perform satisfactorily. They complained about low payments, efforts needed for treating the tanks at a higher level, irregular supply of TCL etc. People were hesitant to take any initiative in the process of maintenance of the water sources and proper distribution. While both the group 1 and group 2 alternate sources except the hand pumps showed poor quality of water throughout the year, they need to be maintained properly if to be used for drinking water. Identification of the hand pumps as safer source diverted people towards its use more than the open wells. However, an appropriate drainage system and recharging of the ground water are essential for a sustained and clean supply.

Several observational studies indicate significant decline in water contamination after collection from the sources. Also covering of the storage vessels in the households has shown to reduce the contamination (Wright et al. 2004). In this study, while the quality of water samples at the end point depended largely on the source, external contamination due to direct water withdrawal from sources was diserved largely in summer due to reuse and repeated handling at the household level.

Despite frequent meetings and demonstrations about the risks of drinking polluted water, it required about 7-8 months for acceptance of the proposed interventions. Diverse responses were noted from the three different areas. Differences in educational as well as socio-economical levels of people in three areas appeared to be significant for the acceptance of these changes. Area A (especially Parinche), a more accessible and affluent community showed a comparatively rapid and sustained acceptance followed by area B and area C. Besides, different capacities and efforts of the local health functionaries to interact with the community influenced the responses in the three areas. Several positive changes (Box 1) were then observed. Although the health functionaries and eco group children had major contributions in this movement, there is a need for integrated interventions to bring about sustainable changes in the community. Supplementation with specific information is possible now with its retrieval / availability from several national and international sources.

An increased participation of people also resulted in influencing the functioning of local governing bodies to take decisions that are in the interests of the local community. People became aware of their rights for adequate and clean water and were willing to contribute both money as well as human efforts to find solutions. For instance, people from Parinche contributed for the cost of an additional water supply pipeline from Veer dam which otherwise was supplied to distant villages (Box 1). More economic as well as administrative powers at the local level could help in finding rapid and locally suitable solutions in future. The issue of water quality is inseparable from its availability as well as proper sanitation practices (Howard et al. 2003) as also proposed in the recent movements such as “Jal Swaraj” (water independence) in India (www.rainwaterharvesting.org/jalswaraj2.htm).

The relationship between prevalence of diarrhoea and drinking water quality is more complex. Most of the water treatment and storage interventions, sanitation practices and health education in several other studies have shown to be effective and yet high indicator bacteria counts were seldom associated with diarrhoea (Gundry et al. 2004; Hinrichson et al. 1998). A few diarrhoeal cases were noticed in the present study mainly in the rainy season when ample of water was available in the main sources and the alternate sources were barely used. However, no major epidemic was recorded. An increase in the annual diarrhoeal prevalence from 4.6% to 7.1% in the population covered by the project was observed at the end of the study. The marginal increase could be the result of intense intervention in case diagnosis and recording by the FRCH health functionaries who were undergoing an in depth training for several health issues including diarrhoea during the study. More recent figures in the year 2004 indicate 3.1% diarrhoeal diseases in area A, 4.5% and 4.2% in area B and C respectively. The extent of diarrhoeal diseases in the population therefore did not coincide with the improved quality of water indicating that the conventional potability indicators may not reflect directly the current situation of water borne diseases. Other factors such as the immune status of the community and physiological relationships between bacterial species within a water source may also play an important role. In preliminary studies undertaken at the FMR, it was observed that the heterotrophic bacteria present could affect the survival and / or virulence characteristics of pathogens from the same ecological niche. This is an area for future studies.

Soon after our intervention, several other non governmental organizations (NGOs) were involved in the project area in the field of water conservation, rain water harvesting techniques, equity in water distribution, water auditing giving preferences to drinking water and agricultural sector over the industrial area for provision of water.

The community activities initiated during the study have become a regular feature in the valley due to the symbiotic effect of these multiple interventions. School children undertake the testing for water quality of their community as an ongoing activity. People are willing to take initiatives in several health and hygiene issues like water supply and quality management with guidance of the FRCH staff members and health functionaries. These self help measures need however, a well-synchronized expansion plan to achieve long-term benefits to the community. The study has been helpful in demonstrating an approach for mobilizing the community and encouraging it towards building a more self-reliant problem solving capacity.

CONCLUSIONS

An approach for consolidating a rural community's response towards accessing potable drinking water is described here. The cyclical approach of multi-level surveillance, feedback to community and engendering of technological competence to the community was able to spark interest, capacity and response in different segments of the community. That this response was evoked in a draught-prone period when water availability was scarce testifies to the power of such an approach. Multi-level empowerment in a community also ensures the sustainability of such an approach which should extend also to local governance institutions such as Panchayati Raj Institutions.

The outcomes of such interventions should not be restricted to levels of diarrhoeal morbidities. The generation of empowerment and awareness through the process are important indicators of success as are the increasing volumes of case histories testifying to concerted community action towards their local water resources.

BOX 1 :

- People from Parinche, New Hargude and Kambalwadi (area A and B) filed a petition to the village developing officer after knowing that the water from nearest Veer dam was being provided to the city of Saswad 30 kms away rather than the proximal villages nearby facing water shortage. The issue was also followed up with the help of local newspapers.

- In New Hargude (area B), the construction of a tank was done by a local contractor thereby reducing the cost, improving the quality of work as well as the long term maintenance.

- A tank valve in Kambalwadi (area B) was damaged leading to leakage. Water could not be detained for chlorination. On realization of the importance of chlorination, a new valve was sanctioned in the village meeting and replaced with help of the FRCH staff.

- In the same village, a farmer did not take the crop instead he reserved the well water as drinking water source for the village.

- In Parinche (area A), repair to a damaged hand pump was delayed as no spare cylinder was available at the Gram Panchayat. People then voluntarily contributed Rs. 950 per family and replaced the new cylinder.

- People in Khengarewadi from area B objected to the provision of water from a nearby minor irrigation tank to a receiving station instead of their village. On disagreement from the contractor to stop the work, they discussed the issue in the village and decided to fight for their rights to the Gram Panchayat. Although men were initially hesitant, women in the village contacted the concerned officer and questioned him. Although they failed to stop the supply as it was sanctioned much before without any objection from the community, the entire issue increased the awareness in the community for their rights of adequate water.

- Eco group children in area C arranged for a proper drainage system from the tank that served to water the plants nearby thus setting an example of water recycling.

- Desilting of the well in area B was voluntarily done by women and school children thereby inspiring the youth to continue the activity.

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Table 1 : Survey of the six villages

Information	Area A		Area B		Area C	
	Parinche	**Shindewadi**	**New Hargude**	**Kambalwadi**	**Kharadwadi**	**Kondkewadi**
Valley (area)	Parinche	Parinche	Pangare	Pangare	Kaldari	Kaldari
Altitude(metres)	580	660	605	608	810	860
Accessibility	Easy	Difficult	Easy	Difficult	Easy	Difficult
Population	2000	175	264	264	112	250
Educational facilities in village	Junior college	Primary school	Primary school	Primary school	Junior college 2 km away	Primary school
Main occupation	Agriculture, milk vending	Agriculture	Agriculture	Agriculture	Agriculture	Agriculture
Basic amenities available	Yes	Few	Few	Few	Few	Few
Regular medical facilities	Government and private	Not available	Not available	Not available	Not available	Not available
Use of traditional herbal medicine	Occasionally	Commonly	Commonly	Commonly	Commonly	Commonly
Water tank capacity (litres)	1,00,000	15,000	10,000	14,400	5,600	3,000

Table 2 : Availability of tank water (Total sample collections scheduled = 7)

Village (Area)	Sample collected	Sample not collected	No supply	No supply at the time of sampling	Electricity failure	Tank valve under repairs
Parinche (A)	6	1	1	-	-	-
Shindewadi (A)	2	5	-	3	2	-
New Hargude (B)	5	2	1	1	-	1*
Kambalwadi (B)	1	6	4	1	1	-
Kharadwadi (C)	4	3	-	1	2	-
Kondkewadi (C)	0	7	5	1	1	-

* Water could not be stored in the tank but was being supplied at the time of sample collection.

Table 3 : Quality of group 2 alternate sources during the study year

VILLAGE → (AREA)	**PARINCHE (A)**		**SHINDEWADI (A)**	**NEW HARGUDE (B)**	**KAMBALWADI (B)**		**KHARADWADI (C)**		**KONDKEWADI (C)**
SOURCE →	W1	W2	W	W	W1	W2	PL	W	S
RESULTS ↓									
Polluted	8	7	7	4	3	4	7	4	6
Acceptable	0	1	1	4	5	3	1	3	2
Excellent	0	0	0	0	0	1	0	1	0

Key : W - Well; W1 & W2 **-** Two wells from the same village; PL - Percolation lake; S - stream.

Table 4 : Quality of household water in relation to the source

	Relation to source	**Area A** n =19	**Area B** n=17	**Area C*** n=17
		%(Incidence)	%(Incidence)	%(Incidence)
1	Tank and stand post clean; household clean	42.1 (8)	47.1 (8)	82.4 (14)
2	Tank and stand post polluted; household polluted	26.3 (5)	35.3 (6)	0 (0)
3	Tank clean and stand post clean; household polluted	0 (0)	0 (0)	0 (0)
4	Tank and stand post clean; household polluted	0 (0)	11.8 (2)	17.6 (3)
5	Tank and stand post polluted; household clean	31.6 (6)	5.9 (1)	0 (0)

* - Area C represents only one village Kharadwadi as no tank water could be collected in Kondkewadi.

Table 5 : Acceptance of the interventions in the families from the three areas at the end of the study

Interventions	**Acceptance (%)**		
	Area A (n = 400)	**Area B (n = 106)**	**Area C (n = 22)**
Copper wire/ vessel	47.5	20.7	100.0
Mother solution	47.5	71.7	9.1
Tap fitted to vessel	21.2	85.7	27.3

FIG 1 : QUALITY OF PIPED WATER IN **PARINCHE (AREA "A")**

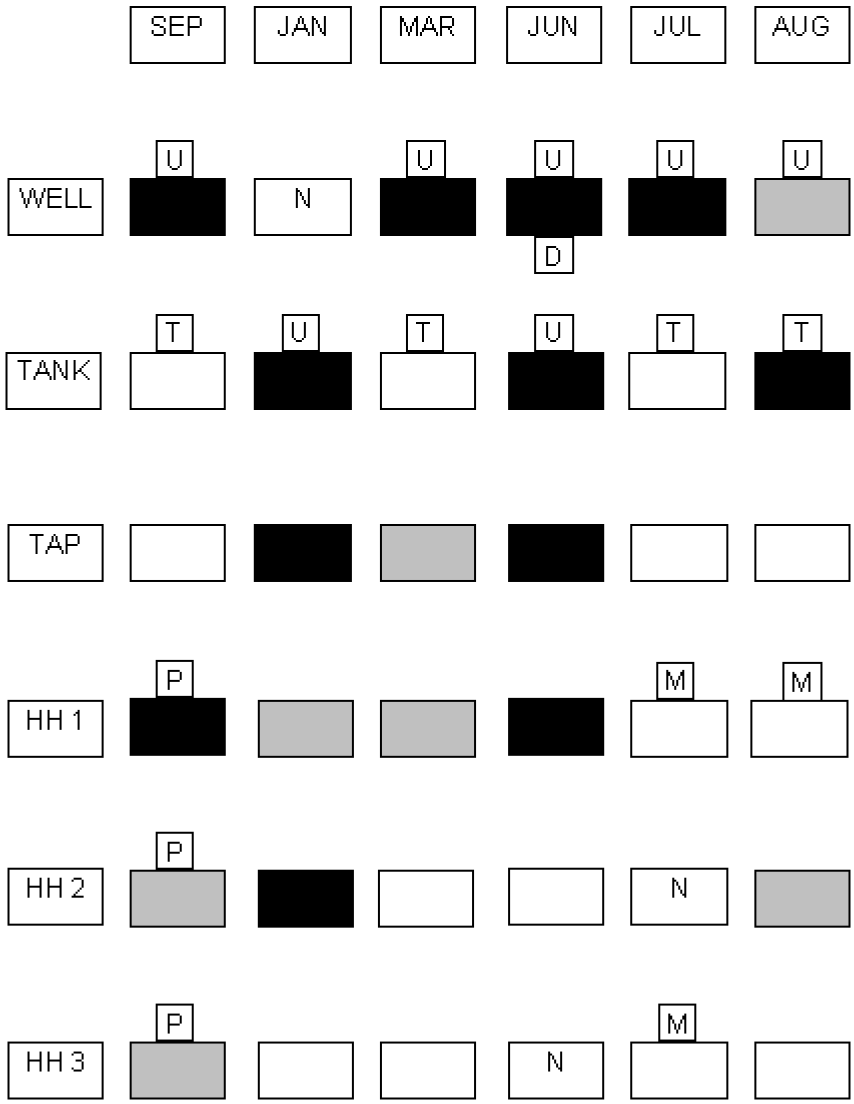


FIG 2 : QUALITY OF PIPED WATER IN **SHINDEWADI (AREA "A")**

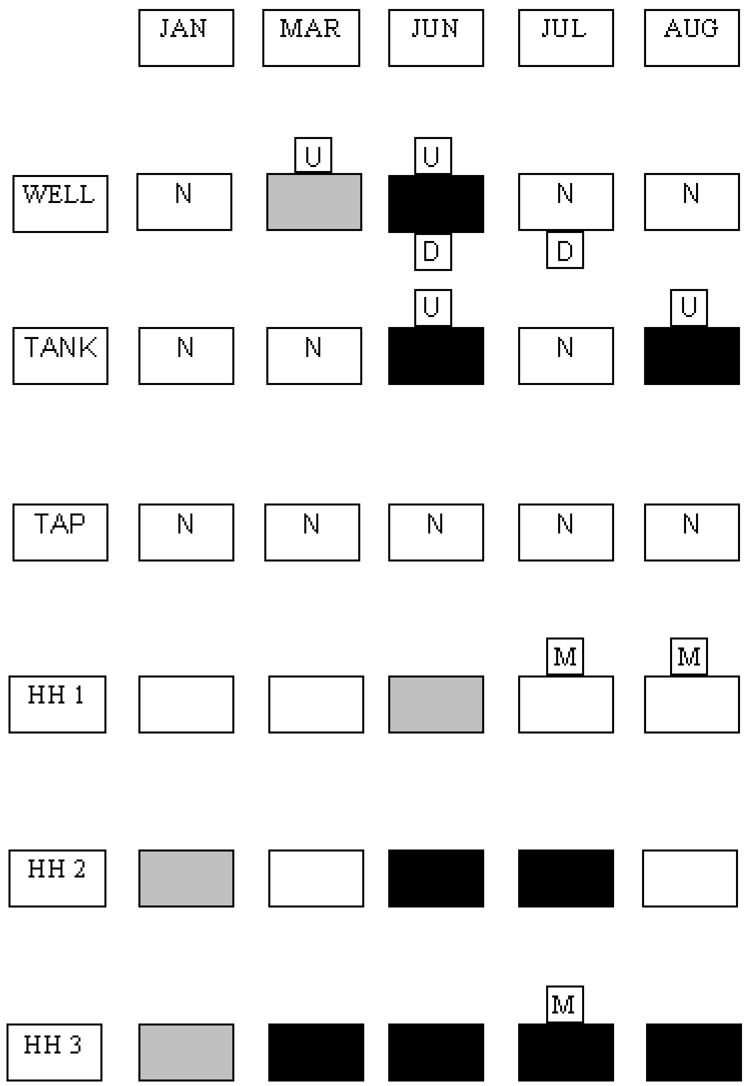


FIG 3 : QUALITY OF PIPED WATER IN **NEW HARGUDE (AREA "B")**

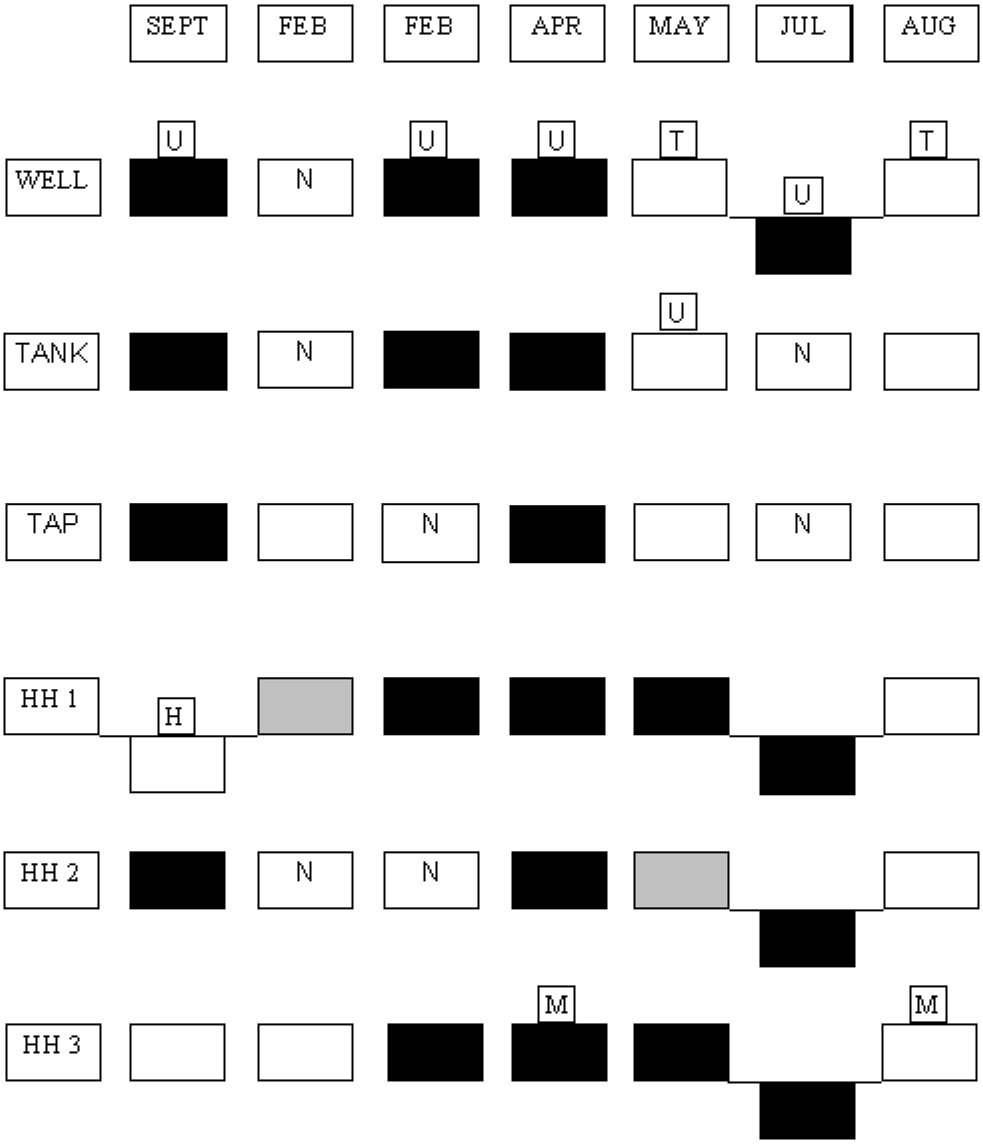


FIG 4 : QUALITY OF PIPED WATER IN **KAMBALWADI (AREA "B")**

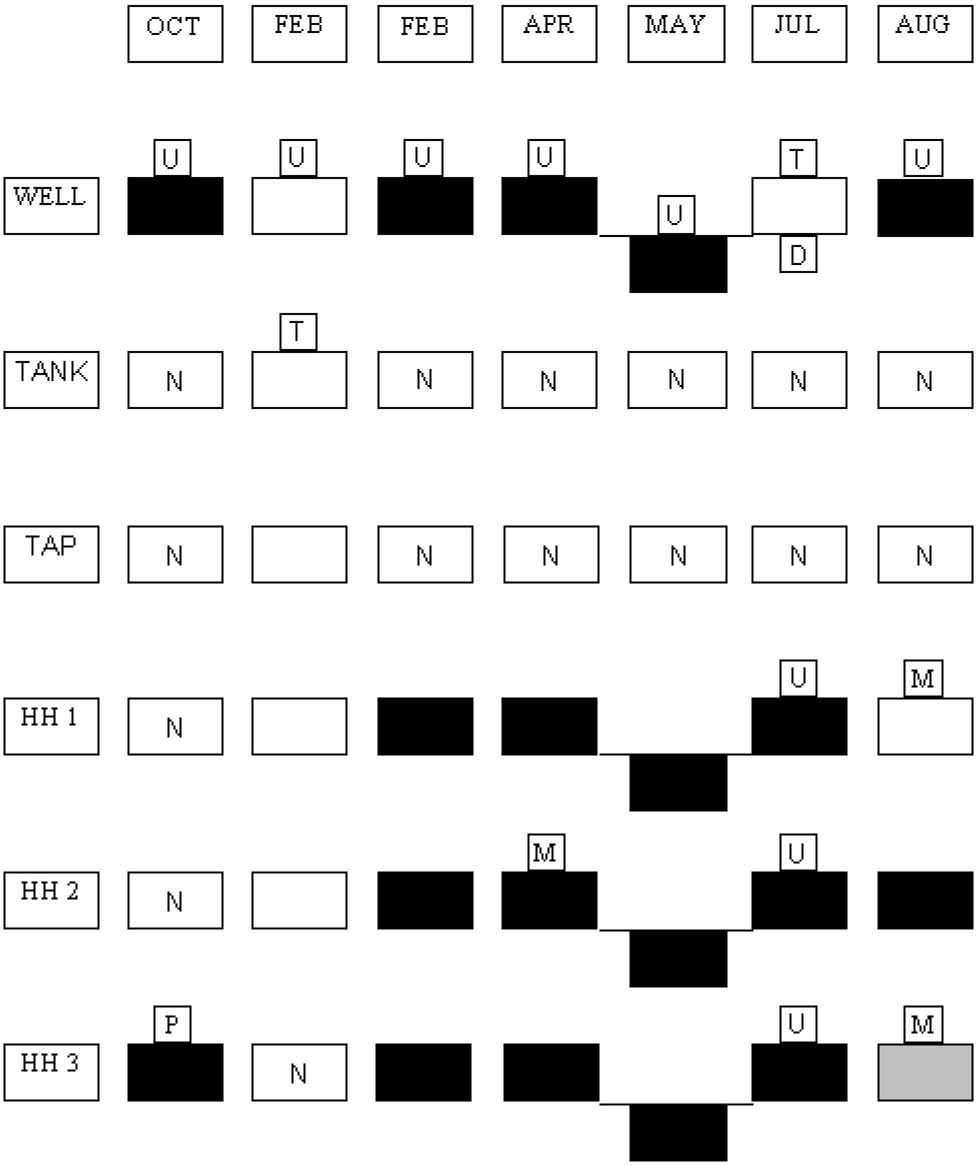


FIG 5 : QUALITY OF PIPED WATER IN **KHARADWADI (AREA "C")**

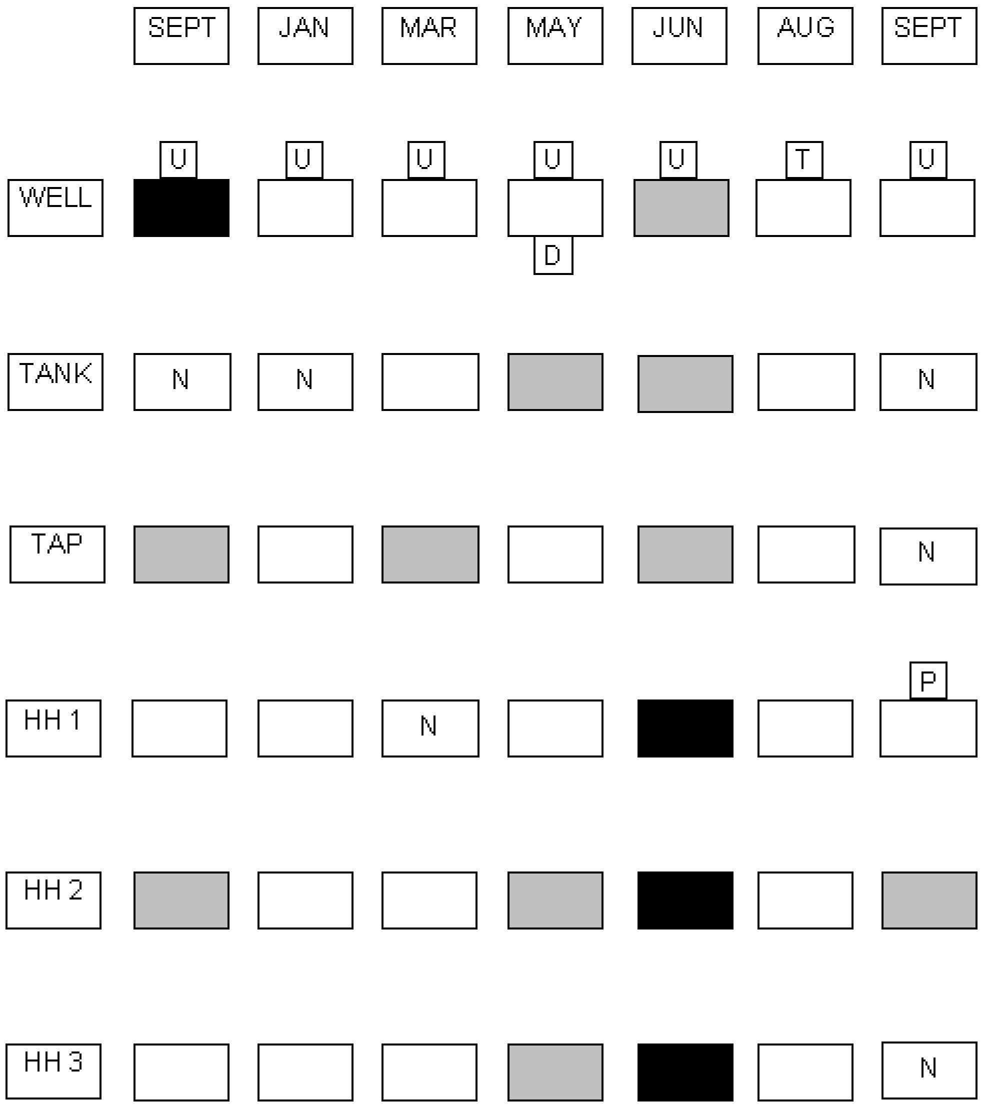
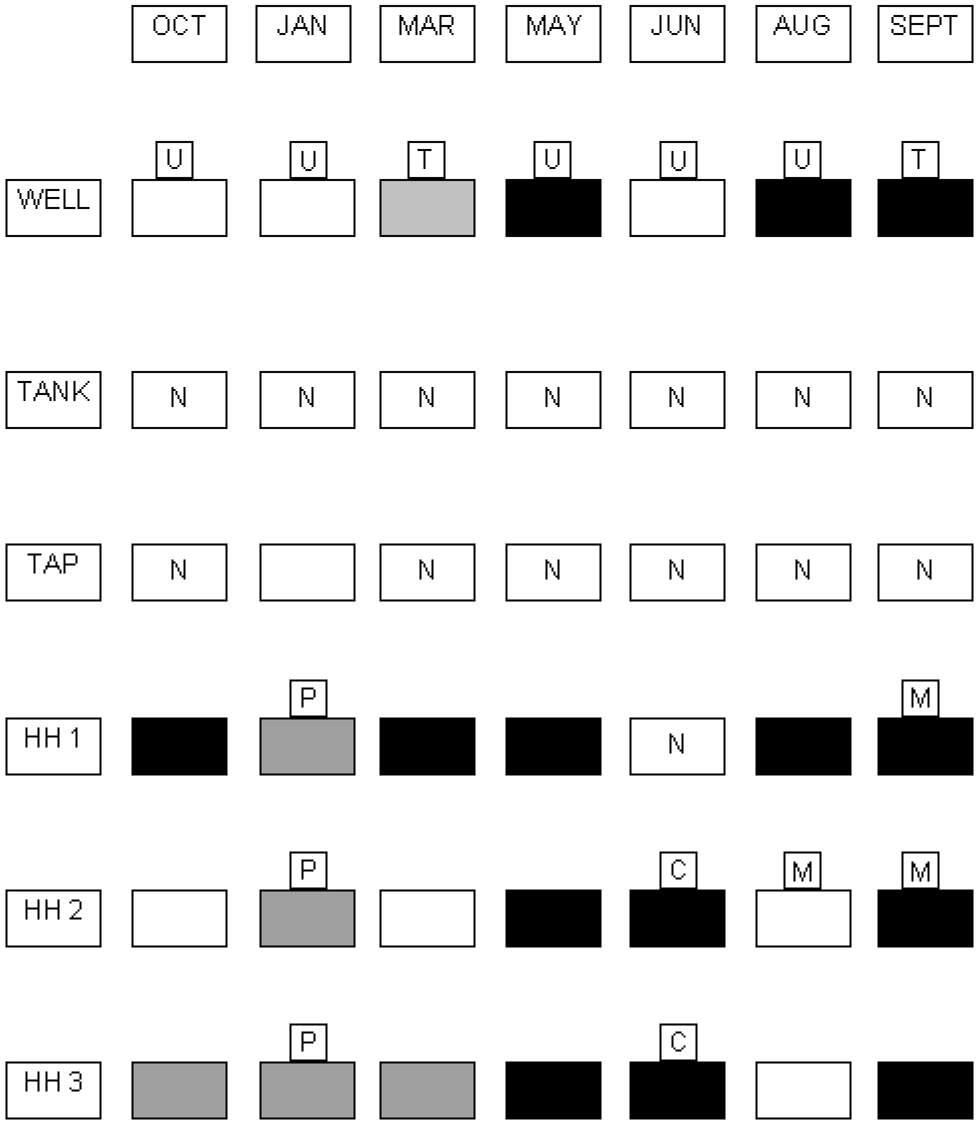


FIG 6 : QUALITY OF PIPED WATER IN **KONDKEWADI (AREA “C”)**



KEY :

U	UNTREATED		EXCELLENT
T	TREATED		ACCEPTABLE
D	DIARRHOEA RECORDED		POLLUTED
P	PREVIOUS DAY SAMPLE	H	FROM HAND PUMP
M	MOTHER SOLUTION ADDED		FROM ALTERNATE SOURCE
C	COPPER WIRE IMMERSED	N	NOT COLLECTED