Role of Chlorun on Water Disinfection and Impact on Community Health

-A Case Study

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BACKGROUND

Introduction

Access to safe drinking water remains urgent necessity as 30% of urban and 90% of rural households still depend on completely untreated surface or groundwater (Rakesh et al 2005). While access to drinking water in India has increased over the past decade, the tremendous adverse impact of unsafe water on health continues. The World Bank (1993) estimates 21% of communicable diseases in India are water related. Of these diseases, diarrheal alone killed over 700,000 Indians in 1999 (estimated) – over 1,600 deaths each day. The highest mortality from diarrhoea is said to be in children under the age of five, highlighting an urgent need for focused interventions to prevent diarrhoeal disease in this age group.

Despite investments in water and sanitation infrastructure, many low-income communities in India and other developing countries continue to lack access to safe drinking water (Srikanth 2009). Regardless of the initial water quality, widespread unhygienic practices during water collection and storage(Marra and Feachem 1999) overcrowding and limited access to sanitation facilities perpetuate the transmission of diarrhea-causing germs through the faecal-oral route. Majority of inland rivers and lakes are contaminated (Eisenburg et al 2007).

The drinking water supply sector has mostly targeted the water borne transmission of pathogen, The most common method employed is the chlorination of drinking water at treatment plant and in the distribution systems. Chlorination is considered essential to make it safe for drinking , especially when is obtained from surface water sources. While there is universal acceptance and use of drinking water chlorination but there is ongoing debate on mode of chlorination and provision of bacterially free safe water to the rural community (caincross and Kolsky 1996).

Although majority of the rural India shifted from surface water based supply systems to ground water based, there are still thousands of habitations that are covered through surface water particularly habitations located on the river banks, perennial streams, ponds and other bodies .Chlorination remains a major choice of disinfection of surface water in urban India. While in Rural India the central and state agencies promote chlorine bleach (bleaching powder) for disinfection of the community water sources, including wells and overhead water storage reservoir. The limitation of this practice at field level include

a) This practice is often carried out on ad-hoc basis at community level by health workers who are not trained in dosage and safety measures and bleaching powder is often seen dumped indiscriminately into the large water-storage tanks/wells, leading to excess residual chlorine.

b) The residual chlorine is not monitored on regular basis and this practice is leads to excess chlorination and sometimes lack of disinfection and this leads to spurt of diarrheal epidemic in places when water is contaminated and monitoring mechanism is not place. In the absence of infrastructure, trained manpower in regulating the disinfection of water in rural India lead to widespread occurrence of diarrhoea especially during summer and rainy seasons.

Bleaching powder also suffers from following disadvantages when adopted as mode of disinfection

Chlorine concentration in bleaching powder is not stable because of

- hygroscopic nature
- Packing in PE Bags
- Affected by heat
- Loss during transportation
- Potency reduction during storage
- Effect of UV Rays
- Storage

Bleaching powder is usually withdrawn in small quantities time and again from PE bags and thus the concentration reduces considerably, because of exposure to humid atmosphere. Since bleaching power contains only 25% available chlorine, its use involves the extra expenses transporting and storing the insert material. Bleaching powder is an Therefore provision of uninterrupted safe water for the communities calls for effective replacement of bleaching powder with superior technology that provide effective disinfection with well regulated dosing mechanisms.

Under the present circumstances, one of the ideal choices to obtain safe water for the community is to promote effective and convenient ways of disinfection using improved technologies along with hygienic water-storage practices.

One of the ideal choice is to evaluate the impact of modern disinfection technology like ChloRun a fully automated version of disinfection in the rural community for the provision of 24/7 safe water supply and study the impact in controlling diarrheal disease in a village where the source water is highly contaminated by microbes with reported incidence of diarrhoea.

Technology

The ChloRun System is based on a world-wide known sanitizing agent, approved by World Health Organization (WHO) and the National Science Foundation (NSF), ChloRun is produced by ICL-IP, a world leader in water treatment chemicals, certified to ISO-9000 quality management standards.

The Advantages of the ChloRun System over traditional system

Easier– No need for expert training or handling; fully automated system.

Safer – Contains no hazardous materials; No spillage of hazardous solutions, completely safe for your employees and your customers.

More Convenient – High Cl concentration, easy to transport and store available even in remote areas; fresh solution can be made on-site.

Based on these advantage the client ICL requested EDS to conduct field trail of this technology for carrying out health impact assessment in Rural India which has ideal mix of criteria like high level of contamination and surface water sources along with willingness of the community to participate in the study.

1. Site selection criteria for carrying out the assessment

Following criteria is being adopted for piloting Cholrun technology and health impact assessment of community accessing water treated by this technology.

- Village ideally should have surface water based supply system, particularly supplied through OHRS(overhead reservoir supply) where chances of contamination are higher
- Perennial surface water source that is highly contaminated with fecal Coliform at least 200-300CFU/100 and contamination should be consistent for major part of the year or at least during study period
- Absence of any other interventions during study period either by government or other agencies
- Reported occurrence of waterborne especially diarrhea
- Community Willingness to participate in the study & community support in accepting technology
- Microbiological laboratory should be within approachable distance for regular water quality analysis using MPN technique
- Presence of local agencies who can collect data , monitor the health outcomes of the technology and mobilize community to impart software component of the project

- Suitable control village nearby accessing contaminated water to serve as control
- Presence of significant population density with adequate number of children between 0-5 years
- Village head and preferably government participation for scaling up of the technology
- Willingness of community to pay at least for O&M (chemicals and electricity bills)

Site for the pilot study

Based on these Criteria a Village by name Namiligonda was selected in Warangal district which is located 100km from the Hyderabad city.

Village background:

The NAMILIGONDA village has population of 3200. With 498 Households is geographically located beside Ghanpur railway station. This village is located near to Hyderabad to Warangal High way (Fig 1). medical college which as a well equipped pathological lab for conducting bacterial testing by MPN method is 20km from the site

2. Water Source:

A. Large surface water tank (pond) separates the village into two half. One half which is larger in size is supplied through over head reservoir of 20,000gallons of water. The water is pumped from 3 wells which is located near 3 corner of the large pond receives water from adjoining contaminated pond which gets filled during rainy season. All along the catchment of the pond open defecation is practice. The water from the well and the reservoir is highly contaminated by fecal coliform. The water is pumped into overhead reservoir and supplied to one part of the village through household piped water scheme

Preliminary analysis of water quality carried out in state district laboratory revealed 450CFU in well water and 250 CFU/100ml in water supplied through Reservoir. Bleaching powder is used for treatment and applied once or twice in the week

Nature of the problem

Safe drinking water is a big issue in this village. Water quality concern is expressed by the village community. People suffered from waterborne diseases and this being regular feature during rains. However, no record is maintained either by any agencies on extent and on magnitude of this problem.

Broad objectives of the project: To study the health impact of the community accessing safe water through Chlorun technology

Specific objectives

- Conduct baseline survey of the village including demographical patterns, water source inventory, household information including data on sanitation, hygiene in both intervention and control village.
- Conduct household survey on diarrhoea among children and adults in intervention and control village
- Conduct village level meeting for community level participation for the study
- Identification of site for installation of chlorun Technology
- Regular monitoring of water quality, residual chlorine, microbiological analysis of water samples including water sources, household sources in intervention and control part of the village
- Conduct health impact assessment (cohort study) on target community especially among children (0-5 yrs) in the intervention village(Namilkonda)against control population drinking contaminated water.
- Correlate and compare the data on intervention and control on role of effective disinfection in reduction of Diarrheal diseases among adult and childrens

Methodology

Study area

The intervention took place in a village called ''Namilkonda'' located in 100 km north of Hyderabad city, india. For comparison, water quality and incidence and incidence of diarrhoea were also monitored in second village adjoining the intervention village. The two villages were identical with respect to layout, ethnic composition and socioeconomic status. They are situated 1.5 km apart and had separate water supply sources and both the village are dependent on large pond that separates the 2 villages (fig1). The intervention village received piped water supply that was chlorinated water supply from chlorun technology. The non-intervention village were dependent on ground water through hand pump that was grossly contaminated from seepage received from the contaminated pond.

Fig:1. The map indicating the site of intervention

Household selection

All household from the 2 villages that had children aged less than 5 and that primarily dependent on ground water (hand pump) in the case of control village and piped chlorinated water in the intervention were selected for the study. This resulted 105 children in intervention village and 75 in the control village (Table 1,2,3)

Table1. Household details

S.No	Average number household	Total Number of adults in the	Total number of children (0-5) in the	Average number household	Total Number households	Total number of children

	using safe water in the intervention village	intervention village	intervention village	drinking contaminated water in control village	in control	(0-5) in the control village
	195	195 families)	103	225	300 families	75

Table2. Age wise segregation of children (0-5) in intervention village

S.No	Total number of children surveyed	Total number of children in age group 0-6months category(baseline weight-march weight)	Total number of children in age group over 6 months-2 yrs category	**Weight gain** among children in the age group 6months months 2 years category(baseline weight-march weight	Total number of children (2-5 years) in the control village
	103	9	35	**35**	59

Table 3. Age wise segregation of children (0-5) in control village

S.No	Total number of children surveyed	Total number of children in age group 0-6months category	Total number of children in age group over 6 months-2 yrs category	Total number of children (2-5 years) in the control village
	75	8	19	48

Chlorination

Water supply to Namilgonda village was selected for intervention because the village had overhead water storage reservoir and piped water distribution that received the pond water and was chlorinated using traditional bleaching powder once in a week. Therefore the water supply to the intervention village received intermittent chlorination only. In the community meeting that took place in August 2010 , the people from Namilkonda village expressed their interest in, and support for instalment of ''Chlorun'' technology for 24/ 7 safe water supply.

Before the onset of the study, the residual chlorine was measured along with bacteriological analysis of water sample from household and from the reservoir.

Fig:2 Discussion on the chlorun Technology

Data collection

In August 2010 all the selected families were visited to explain the purpose of the study and seek their agreement to participate through informed consent. All the selected household agreed to participate, and the children received a unique identification number. From September 2010 two trained health workers (female) visited all the village household on weekly basis . The presence of female assistant as assistants made it possible to interview the months of the children who are primary care givers on diarrhoea episodes and monthly and weekly visits

a) Household visits & assessment : Household surveys and monthly were conducted in the enlisted families in both intervention and control villages. The survey include baseline data and monthly information of certain parameters like sanitation coverage and hygiene practice were also obtained .

Fig : 3 Household interviews

b) Monthly weight measurement**:** Trained Health workers were deputed to undertake measurement weight of children in the range of 0-5 years in both intervention and control village. Weekly information on diarrhoea episode among the children in both intervention and control part of the village were also obtained.

Fig 4 Health workers monitoring child's monthly body weight

Water sampling and analysis for Escherichia coli

Pre-intervention water quality data was done for both intervention and control village

Microbiological testing: Water samples of treated water from reservoir and at three points in the household (near reservoir, middle part of the village and end part) were collected , transported and analysed as per APHA method. E. Coli colonies were enumerated and reported as numbers of colonies per 100ml. Of water sample. Water sample was analysed in the standard pathological laboratory in government medical college by using MPN technique .

However, for regular weekly testing H2S vials (Hydrogen sulphide) was adopted as indicator test for bacteriological safety at household and community sources in both intervention and control.

c) **Residual chlorine test**

Residual chlorine was tested using chlorescope on daily basis in the intervention village at three points one near overhead reservoir other in the middle of the village and the third at the end point of the village.

Fig 5. Monitoring of Residual chlorine

Data analysis

diarrhoea , as defined as three or more loose or watery stool per day were calculated for the selected children's

aged less than 5 years in the both the village. The sanitation and water storage as important practices of hygiene practices in prevention of diarrhoea were also taken into consideration in the present study. Comparison were made between intervention village and control village on the risk of diarrhoea among children using chlorinated water derived from Chlorun technology and children using un chlorinated water from hand pumps in the control village.

Results

A. Water quality

Results of water of the both intervention village and control village are found to be highly contaminated during pre-intervention period. The coliform count was consistently over 100 per 100 ml. The source of water is surface water pond that was highly contaminated by faecal colifom due to open defecation around the pond catchment area. Although in the intervention village, the water supply was chlorinated but the traditional method of using bleaching powder done intermittently could not offer effective chlorination and provision of safe water. Therefore this traditional method of chlorination was replaced by 24/7 automatic chlorination using chlorun technology commissioned as pilot (Fig1) that has ability to provide enough residual chlorine at far end of water supply. After switching to automatic dosing of chlorine in the village A, the water supply improved resulting in drastic reduction of E. Coli which was not detected during October-march during the intervention period (table 6). The residual chlorine in the water were measured at the water supply at the end of the village revealed a concentration of 0.5ppm

Table 4.Coliform count at different points before intervention (CFU/100ml) In Village A (intervention village)

LOCATIONS	Total number of water samples	September 2010(CFU/100ml)
Reservoir	5	100
Households near Reservoir	5	200
Households at the middle point of the reservoir	5	250
Household at the last point from the reservoir	5	200

This shows the residual chorine level is important in reducing the coliform levels in the water

Table 5 Six month Residual chlorine in the intervention Village

	MONTHLY AVERAGE Residual chlorine DETAILS					
LOCATIONS	October	November	December	January	February	March
Reservoir	1.6	1.5	1.3	1.6	1.2	1.3
Households near Reservoir	1.2	1.1	1.0	1.3	0.9	1.0
Households at the middle point of the reservoir	1.0	0.9	0.8	1.0	0.7	0.9
Household at the last point from the reservoir	0.5	0.4	0.5	0.5	0.3	0.5

Table 6. Six month coliform count details in the intervention Village

LOCATIONS	Coliform count CFU/100ml					
	October	November	December	January	February	March
Reservoir	ND	ND	ND	ND	ND	ND
Households near Reservoir	ND	ND	ND	ND	ND	ND
Households at the middle point of the reservoir	ND	ND	ND	ND	ND	ND
Household at the last point from the reservoir	ND	ND	ND	ND	ND	ND

*ND: Not detected

Table 7. Control village details water quality details

LOCATIONS	Coliform count CFU/100ml					
	October	November	December	January	February	March
Borewell	1600	1800	Above 2000	1600	1600	1600
Handpump near borewell	1200	1400	850	650	1600	Above 2000
Households at the middle point of the village	150	200	250	350	200	80

There is clear cut impact of chlorination on the occurrence of diarrhea in both control when compared to intervention village(table 8). There was more than 90% reduction of diarrhoea among both adults and children's in the village that has received chlorination from the automated system when compared with baseline data of September 2010 . The diarrhoea episode among the village B in both adults and children were high through the study.

Table 8. Water quality in the village A (Intervention village)

	Coliform count CFU/100ml					
LOCATIONS	October	November	December	January	February	March
Reservoir	ND	ND	ND	ND	ND	ND
Households near Reservoir	ND	ND	ND	ND	ND	ND
Households at the middle point of the reservoir	ND	ND	ND	ND	ND	ND
Household at the last point from the reservoir	ND	ND	ND	ND	ND	ND

Table 9. Incidence of diarrhoea in village A and village B (Control)

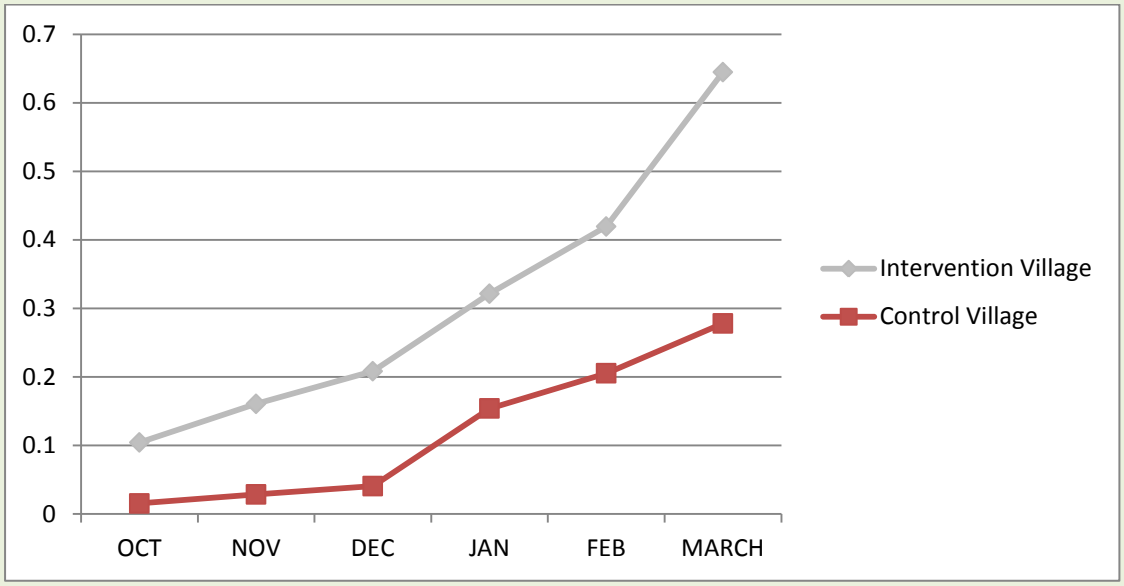
DIARRHEA IN INTERVENTION AND CONTROLLED VILLAGES																	
INTERVENTION VILLAGE(195 FAMILIES)									CONTROLLED VILLAGE(150 FAMILIES)								
BASE LINE(August)	SEP		OCT	NOV	DEC	JAN	FEB	MAR	BASE LINE		SEP	OCT	NOV	DEC	JAN	FEB	MAR
ADULTs	35	15	3	2	NIL	NIL	nil	Nil	ADULT	45	42	35	29	35	28	34	36
Children (0-5	16	9	2	1	NIL	1	nil	NIL	CHILD	19	9	11	16	9	13	16	18

B. Baby or child weight

The body weight of children aged 0-5 was monitored every month by health assistant recruited for this purpose. The total number of children monitored under different age group in the category of 0-5 is given in both the villages A & B control is given in the table 2&3. The incremental weight increase in the babies is a indicator of healthy growth . The result is presented in Fig 6 are the monthly mean growth of babies during the intervention period (October 2010-march 2011) it is

clear that the growth of the babies showed steady increase in the village A compared to baseline levels in the village that had fewer episode of diarrhoea and household that received with safe water from automated system . This was in sharp contrast to the decline in the growth among the babies in the village B that was subjected to contaminated water from bore well that contained coliform number of more than 1600CFU/100ml.

Fig:7 Monthly mean body weight of children (0-5 yrs) in the control & Intervention village



Discussion:

The study clearly emphasizes the role of effective chlorination that led to improvement of drinking water quality in rural India especially among surface water that is grossly contaminated by faecal matter. The reduction of diarrhea among children and healthy growth patterns calls upon the public authority to ensure mandatory chlorination of rural drinking water supplies in rural India. Maintaining desirable level of residual chlorine is primary importance in reducing the coliforms in the drinking water and thereby decrease the diarrheal episodes among the rural populations. The use of chlorine bleach in water treatment has its own limitation especially in water that is grossly contaminated. The traditional chlorine bleach has very low chlorine content and it solely dependent upon village ‘’water man’’ of the government who is not trained on proper dosing of this chemical and chlorination at village level is done at ad-hoc basis which is the major limitation. This study has clearly indicated the role of effective chlorination and water safety.

Another important finding is that the role of Hygiene and sanitation has minimal impact. The sanitation coverage in terms of household toilet of the both village was over 70% and hygiene practices like hand washings and personal hygiene was routinely undertaken because of large scale awareness

programme undertaken by the other donor agencies working in this area . More than 75% of the persons interviewed revealed that they practice routine hygiene like hand washing.

Another findings that has come out of this interim study is that water quality is major determinant that affects health and well being of the children under 0-5 and adults. In the absence of other variable improvement of water quality can effectively protect the community from the health risk. However, this study was confined to relatively cooler months of the year (October-march) and does not take into the account of seasonal variation especially during summer and rainy season when quality becomes a important criteria and during these seasons due to shortage well as due to gross contamination . Likelihood of the episodes of diarrhea increases manifolds. Therefore, it is recommended that study needs to take care of these variables to get a holistic picture.

Conclusion & Recommendations:

- The Chlorun technology that maintained consistency in disinfection with residual chlorine i.e 0.3 – 0.5 mg/L at all delivery points – is meeting the standards of BIS(Bureau of Indian standards)
- The results indicate absence of Feacal Colliform at all points of distribution line including end point of the village thereby providing water safety .
- The findings reveal that the weight gain in infants and children which is progressive in intervention village in caparison to control village children that showed poor
- The findings prove that ''Chlorun'' that provides automatic dosing with uniform level of residual chlorine can be a effective substitute for conventional Chlorination in rural India that uses bleaching powder.
- Although the reports on baby weight show progress in child health, it requires at least one complete year of observation taking into consideration of seasonal changes especially , the high risk months during the year (Including acute summer and rainy season) when the diarrheal episode increase exponentially in typical rural settings in india.
- Water quality should ideally be studied in 3 seasons to get the trend (Pre monsoon, monsoon and post monsoon). The study period (October-March) can be considered to be relatively risk free season during the year.
- The results indicates that the major determinants for diarrheal disease in the study village was due to high water contamination and role of hygiene and sanitation had not much role .

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