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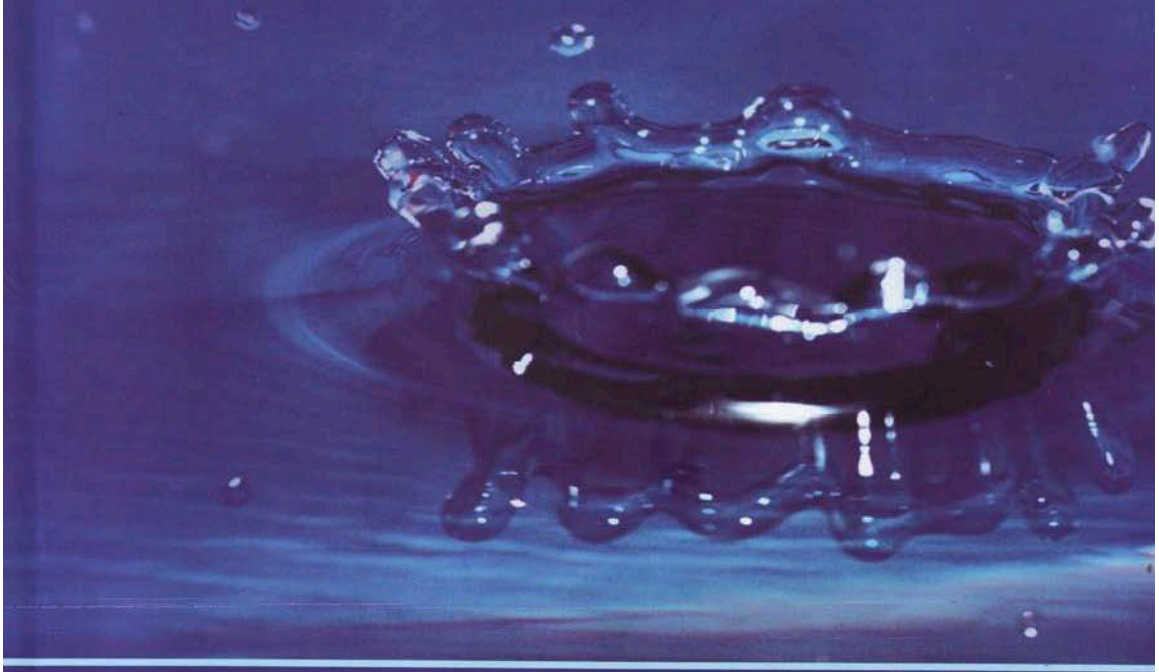

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SONO FILTER: AN EXCELLENT TECHNOLOGY FOR SAFE WATER IN NEPAL

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ABSTRACT

In 1999 arsenic was discovered in the Terai region of Nepal. To address the problem, many development organizations and the government agencies used household filters like the Arsenic Biosand Filter (ABF), three Kolshi, and two Gagri. These technologies have been used in Nepal with varying success. Since 2004, Filters for Families (FFF) distributed close to 3,000 Kanchan filters in four of the Terai Districts (Nawalparasi, Kanchanpur, Kapilbastu and Rautahat). Filters for Families developed a maintenance program for the ABF filter after villages complained their arsenicosis symptoms returned after one year. Maintenance records reveal that over a three year period, 37% of 786 filters were broken and 53% were not used by the households, and maintenance costs in the high arsenic areas more than triples the original cost of the filter after 4 years. Arsenic testing of the ABF filter water, showed similar results, 57 % of the filters did not remove arsenic below the Nepal guideline of 50 ppb, and 63% of the filters didn't remove pathogens below the WHO guideline. In 2007, FFF sought alternative arsenic removal technology system from Bangladesh. At the same time the Million Dollar Global Competition, Grainger Challenge, Golden prize was awarded to MSUK, Bangladesh for the SONO Filter,. The filter was developed after 10 years of intensive research on the Composite Iron Matrix (CIM) by Dr. Munir and Dr. Hussam. The SONO Filter is completely "Green" and no toxic materials are produced by the removal system. Several aspects of the filter are very appealing: the filter and material longevity is more than 11 years; arsenic, pathogens, and 23 other metals including removal of iron, lead, nitrates, nitrites, sulphate, phosphate, magnesium, manganese, aluminium, silicate, zinc, selenium, silver, chloride, nickel, copper, barium, antimony, molybdenum, potassium, strontium, fluoride and ammonia are removed below the WHO guideline for drinking water. New research on virus removal shows promising results. Filter maintenance is very low and village acceptance is high. FFF completed a Nepal SONO pilot project in January 2009. The results are excellent: 187 filters of the 950 filters from the highest arsenic areas were tested. All filters are below the Nepal guideline, 99% are below the WHO guideline. Two of the highest arsenic tubewells were tested monthly for a year, the filter reduces 1010 ppb arsenic water to <10 ppb.

Keywords: Arsenic, SONO Filter, Composite Iron Matrix, Grainger Challenge Award, Nepal, Water Quality,

BACKGROUND

Geographically Nepal is divided into three regions; Terai (18%), Mid Hills (65%) and High Himalayas (15%). The Terai region is rich in groundwater resources, so shallow tube wells were promoted by development agencies as an alternative to dug wells, river and ponds which are host to abundant pathogens. Smith, 2008 estimates that arsenic contamination could affect more than 2.4 million people across 20 districts in Terai home to about 47 per cent of Nepal's population, nearly 90 per cent of who depend on groundwater for their daily needs. Almost 90% of these people use groundwater for drinking water (UNICEF, 2007).

Unfortunately many of the aquifers are contaminated by natural arsenic. In 1999 arsenic was discovered in shallow tubewells in Jhapa District in the eastern Terai. This discovery initiated the Nepal UNICEF Arsenic Blanket Testing program in the Terai. The Department of Water Sanitation and Sewage with UNICEF's support sampled 4,000 tube wells, 200 from each district. The findings indicated that over 3% of tube wells were above 50 ppb (Nepal standard) and over 10% were above 10 ppb (WHO guideline). These studies provided sufficient evidence of arsenic contamination on the intermediate magnitude in the Terai Region, where nearly half (48.84%) of the total population of the country live.

As of 2008, over 600,000 tubewells have been tested by Arsenic Blanket Testing program. Through this program, the top five "hotspot" districts are: Nawalparsi, Bardiya, Kailali, Rautahat and Kapilbastu. In Nawalparasi almost

50% of the tube wells contain arsenic over the WHO guideline of 10 ppb. Nawalparasi District has not only the highest number of tube wells (> 7,000) with arsenic but the tubewell arsenic concentrations are the highest (1010 ppb) in Nepal.

Another problem with water quality in the Terai are contaminants such as, Pb, B, Mo, Zn, F., P, Fe, found in shallow tube wells in Kailali District (Sah and Shrestha, 2007). Smith 2007 found Pb in tube wells in Nawalparasi and Rautahat Districts. Agricultural practices such as high fertilizer and pesticide use may increase certain metals to leach into shallow aquifers. Other metals may have a natural occurrence, since Nepal is a mountainous area with mineral deposits.

In order to properly tackle this problem, Nepal should incorporate several of the best mitigation options. Unfortunately, Nepal does not have an Environmental Technology Verification program like Bangladesh, this leaves Nepal venerable to cheap but poor technologies with insufficient field testing. Such is the case of the ABF filter now called the Kanchan filter. Since 2004, Filters for Families distributed close to 3,000 Kanchan filters. After a year and half, a group of angry villagers from Kunwar walked to the FFF field office in Nawalparasi showing the return of their arsenicosis symptoms. Then FFF conducted both maintenance and filter testing programs of 107 Kanchan filter water. Results showed that only 20% of the arsenic was removed in most of the filters. Three years worth of maintenance records on 786 Kanchan filters show that 53% were not used, 37% were broken, and the cost of replacement nails every year was costly. In fact, over a five year period the cost of the filter is 4 times the original cost of 1500 Nepal rupees.

Table 1: Maintenance Record of the Kanchan Filter (Smith, 2008b)

Filters	Number	Percent%
Monitored	786	100
Not Used	417	53%
Broken	291	37%

The removal of the bacteria is less than 45% and the biofilm takes 10 days to develop after the monthly cleaning. This leaves the user exposed to all pathogens for 10 days a month, one third of the time. The arsenic removal rate is 37% over the Nepal standard of 50 ppb and 49% over the WHO guideline (Smith, 2008).

In Thulokunwar Village, 72 filters were tested (all nails were changed 1 year ago) and show the results which are above 50 ppb which is not safe from Nepal standard.

Bacterial tests conducted by TU students, the test for total coliform shows that about 55% of the bacteria are not removed by the Kanchan Filter (Maden, 2008, and Shrestha, 2008)..

So these all maintenance program revealed that the performance of Kanchan filter is low, therefore drastic measures need to be taken to rectify the problem filters.

SONO FILTER IN NEPAL

Due to the low removal of arsenic and pathogen and high maintenance cost of the Kanchan Filter, in 2007 Dr. Linda S. Smith the Country Director of Filters for Families, took a trip to Bangladesh to search for better options to solve the arsenic problem in Nepal. She visited two areas using pond water, small dug wells, chulli systems from David Nunley's research locations and villages in Sylet. The second group was located in Kushtia, at the MSUK NGO. The SONO Filter designed and distributed by MSUK, removes all bacteria, viruses, 23 metals and reduces 6000 ppb arsenic to less than 8 ppb. MSUK has distributed over 100,000 filters to the high arsenic areas across Bangladesh.

SONO FILTER

The SONO Filter was invented by two brothers, Dr. AKM Munir (Medical Doctor) and Dr. Abul Hussam (Chemistry Professor in the USA). The name "SONO" refers to the Sonogram Lab where the filter was invented

The graph shows the SONO Filter test for 41 filters (400-1010 ppb). Out of 41 filters, 40 filters shows the filter water is 0 and < 10 ppb and one filter is 25 ppb. The filters with 25 ppb was tested the following month, the value went to 0 ppb. So the results clearly reveal that 99% of the filtered water (effluent) is showing the value from 0 to < 10 ppb even with the high arsenic influent water (tubewell).

SOCIAL ACCEPTANCE AND HIGH RELIABILITY

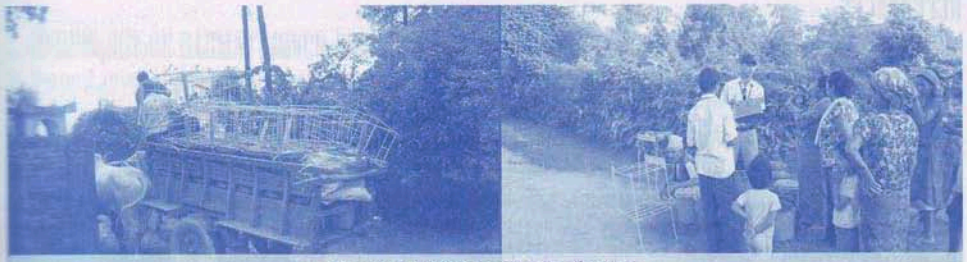

Figure 6: SONO Filter Distribution

One of the most remarkable changes in these communities after using a filter for a short time is their increased energy Villagers also commented on how good the water tastes, how good food cooked in the water tastes, and how easy it is to use. In Thulokunwar Village, the family has 876 ppb of arsenic in their tube well, the Kanchan filter only removed 20% of the arsenic and none of the lead. After drinking the SONO Filter water, they found a noticeable change in their body within a week. Their headaches were gone, no digestion problems, and they had more energy. To honour the filter water they put a scarf on the filter.

Figure 7: Honoring the filter

SONO IN DOLAKHA DISTRICT

Dolakha is a mountainous district of Janakpur Zone in the central development region situated at a distance of 132 km from the capital of the kingdom-Kathmandu. There are many people suffering from bone deformities and possible wrist dropsy. Spring water samples from 3 VDC's were tested for arsenic (As) and Lead (Pb). The tests showed that there was no arsenic but Lead was found about 20 times greater than the WHO guideline of 0.01 mg/l. Therefore, FFF with support from Educate the Children (ETC) installed 11 filters.

Figure 8: SONO Filter in Dolakha

CONCLUSION

Arsenic contamination in groundwater in Nepal is a natural phenomenon. The only solution for 2.4 million people in the Terai is arsenic free water. Arsenic and other contaminants associated with pesticides and fertilizers, (Pb, Mo, B, F, Nitrates, Nitrites, Ammonia) are found in the Nepal's drinking water, therefore, a robust, "Green", long term filter is needed. The SONO Filter" developed in Bangladesh is the best solution to Nepal's contaminated drinking water. The filter has proved it's advantages over other water treatment systems through the last six years in Bangladesh Nepal now has the opportunity to use this award winning technology through Filters for Families' partnership with MSUK. The Nepal SONO Pilot Study supported by FFF, UNICEF,

after ten years of intensive research on the removal material called the Composite Iron Matrix or CIM. In 2007 The Grainger Challenge Million Dollar Prize held by the National Academy of Engineers in the USA awarded the Golden prize to the SONO Filter for the World's Best Household Arsenic Removal System. The global competition of 70 entries was narrowed to 15 finalists. Each final filter system was exposed to extensive testing for several months. The criteria used to measure the filter are shown in Table 2.

The filter water must meet the WHO standard, has no breakthrough, works without any chemical treatment (pre-or post), without regeneration, and without producing toxic wastes.

Table 2: Advantages of the SONO Technology

- Low cost
- No chemical is added
- Manufactured Locally (200 units a day in Bangladesh)
- 20-50 L/hour meets the daily drinking and cooking for 2 families
- Effluent As (Total) < 10 ppb (CL 95%)
- Effluent As (III) < 5 ppb (CL 99.9%)
- No pretreatment of water is necessary- a
- completely nonchemical filtration system.
- No backwashing or regeneration is necessary.
- Removes iron, manganese, heavy metals, nitrate, nitrite and many anions
- Removes pathogens to WHO guideline
- Active Media Life time: 11.5 Years minimum
- Maintenance: Change or wash upper sand layers/yr.
- Waste: Completely nontoxic, non hazardous – passed TCLP, TALP
- Passed several ETVAM test programs
- Water quality: Excellent

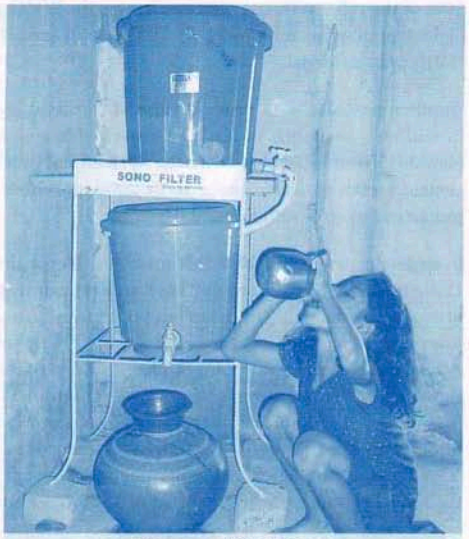

Figure 1: SONO Filter

Several aspects of the filter are very appealing: the filter and material longevity is more than 11 year; arsenic and bacterial removal are close to 100 percent (all below WHO guideline); 23 metals as well as viruses are removed; charcoal in the filter removes any bad taste; maintenance is very low, and village acceptance is high. The removal ability of the CIM does not depend on the water yield (amount of filtered water) nor the arsenic concentration (can be very high-6000 ppb) to be effective (Hussan and Munir 2007). The filter sits on the stand with the red bucket on the top and green bucket on the bottom. The taps are fitted on both buckets so it's easy to collect the water at any time.

The SONO Filter does not require any special maintenance other than the replacement of the upper sand layers when the flow rate decreases. The sand layers (about an inch thick) can be removed, washed and reused or replaced with new sand. SONO Filter is a green filter and if the materials are disposed then it is totally environmental friendly.

MECHANISMS OF ARSENIC REMOVAL

Hussam and Munir, 2008 describe the arsenic removal process of SONO filter as:

1) Corrosion of FeO-composite continuously generates hydrated iron oxides with high specific surface area.
2) Arsenate is removed by surface complexation with HFO (possibly magnetite and maghemite (g-Fe2O3).
3) Mn (ca. 0.2%) in the FeO-composite acts as a catalyst for rapid conversion As(III) to As(V).
4) Removal process is independent of the concentration of As(III) + As(V) input concentration.
5) Excess Ca2+, Fe(II)/Fe(III) and other divalent cations enhance adsorption and complex formation through double-layer charging.

6) Further, cementation reactions produce a porous high surface area insoluble spent material very similar to natural HFO with a high capacity for arsenic removal.

OBJECTIVES OF THE PROJECT IN NEPAL

Problems with the Kanchan filter prompted Filters for Families' Director to seek better arsenic and pathogen mitigation options for their project areas in the Terai. With the approval of the National Arsenic Steering Committee, a SONO pilot project was initiated in 2008 in Nepal.

- To introduce as an alternative technology for effective arsenic and pathogen removal
- To install 950 SONO Filter in several VDCs of Nawalparasi District
- To install filters in homes with tubewells over 800 ppb and perform monthly tests
- To use a filter with low maintenance and high village acceptance

Filters for Families (FFF) hosted a talk program where Dr. Munir explained the SONO Filter Technology to several International Non-Government (INGO) Organizations and Government Officers, in November 2007. A team of technicians and Dr. Munir arrived at the Nepal SONO assembly site in June 2008 to teach Filters for Families and their partners how to make and distribute the SONO filter. Filters for Families is the first INGO licensed by MSUK to make filters outside of Bangladesh.

Filters are produced in the FFF assembly site located in Nawalparasi District. About 100 SONO filters can be produced per day. The filters are distributed from the field office to a village with a technician. The filters are transported by an ox-cart, tractor and flat bed rickshaw. Filters for Families completed the distribution of the SONO Filters in 14 Village Development Committee (VDC) in January 2009 (Figure 2).

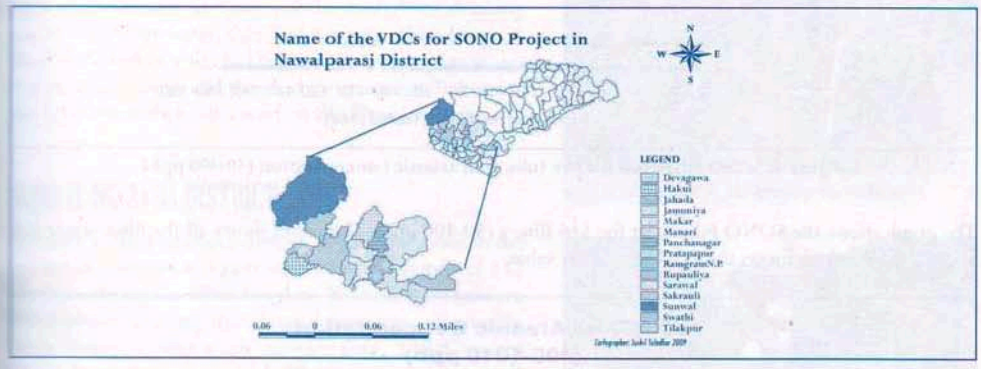

Figure 2: Advantages of the SONO Technology

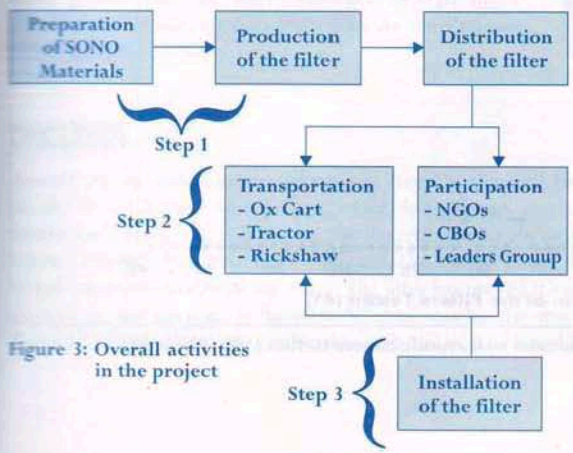

Figure 3: Overall activities in the project

The filters are installed in households, schools, hospitals, government offices, and health offices. Many CBOs, leaders group, and local NGOs were employed in the project for the distribution of the filters.

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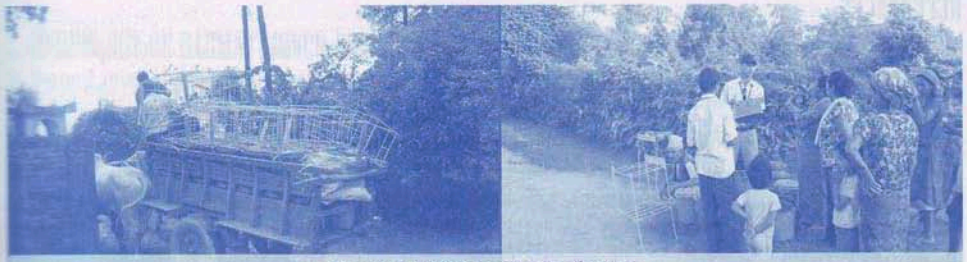

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and DWSS of 950 filters in Nawalparasi is a great success. Once time testing of 186 SONO filtered water and monthly tests of 6 other SONO filters show that the filtered water is 99% (198/200) below the WHO guideline (<10 ppb), and 100% below the Nepal arsenic standard of 50 ppb. The filter has high acceptance among the local villagers in Nawalparasi and many people share that their health is improving within weeks of using the filter water. Households with the high arsenic concentration in their tube well can feel relief because of coming of SONO Filter to Nepal and they can share safe water to all whoever visits their house.

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