FROM UNCOMMON BACK TO THE COMMONS
An experience from North Bihar

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North Bihar is an area in India prone to flooding by major rivers every year. In spite of the area having excess surface water, groundwater has been the main source of water for drinking and irrigation purposes. For years, shallow dug wells had been the principal mechanism of accessing groundwater in the region. In the past, dug wells were considered as a common source for access to groundwater and were maintained and managed by the community. Dug wells, in dispersed and sometimes large habitations, often do not technically qualify as the best access.

The advent and promotion of hand pumps ('*Chapakals*' in local terminology) shifted the paradigm from a community access to an individual access. The *chapakal* technology enabled people access to groundwater in their own backyard, causing a deterioration of the community based mechanism of access to groundwater, i.e. dug wells.

Megh Pyne Abhiyan (MPA) is an attempt by a group of Civil Society Organisations to understand and strategically develop village-based solutions of drinking water security in the flood-prone regions of the Kosi River System in Bihar. MPA's effort of understanding groundwater situation in this highly dynamic setting, facilitated by ACWADAM's technical inputs led to a comparison between the two variable mechanisms of groundwater access. Dug wells in most areas draw water from the shallow unconfined groundwater systems whereas the *chapakals* tap the deeper confined systems as well. Groundwater quality studies have shown that the water from the deeper aquifer has a greater potential to get contaminated with geogenic contaminants like iron and arsenic as compared to the shallow unconfined aquifers, tapped by dug wells. After nearly 20 years of dependence on these *chapakals,* with risks to community health, science and a strategic process of community-mobilisation have enabled communities to back-track to the more community-based approach of accessing groundwater, a Common Pool Resource, through dug wells.

Keywords: *Common source, chapakals / handpumps, iron and arsenic in groundwater, drinking water, groundwater quality, North Bihar*

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BACKGROUND

The state of Bihar is divided into unequal halves - North and South - by the east-west flowing Ganga. The area to the north of the Ganges is a playground of various rivers like the Gandak, Burhi Gandak, Bagmati, Kamla Balan, and the Kosi, to name a few. Although the Himalayas form the northern extremity of Bihar, the topography of the state is dominantly plain. These plains are a part of the Indo-Gangetic alluvium and are extremely fertile which justifies the significant share of agriculture in the states' economy. Most of the rivers flowing through northern Bihar originate in the Himalayas in Nepal. The characteristic of these rivers is that their catchments are very large as compared to their lengths. Thus, the sediment load is huge as are the very high velocities.

The role of groundwater is a known fact in irrigated agriculture. Groundwater management and development programs concentrate on dry land areas. The aim is generally to provide dependable quantities of water, owing to which, the other roles of groundwater have been ignored. Water stressed areas indicate those areas where water quantities are a problem. However, this paper attempts to incorporate the areas with water quality problems also into the definition of water stressed areas. Bihar is the most flood prone state of India. Of India's total flood affected population, 57% belongs to Bihar. 76% of entire Bihar's flood affected population resides in North Bihar. Groundwater studies have been ignored in this region because of "excess" water. On the other hand, groundwater is the only perennial source of drinking water for the entire population of north Bihar. "The problem of *excess* during floods leads to difficulties in *access* to established sources in a habitation. In summer, problems of access are uncommon, but issues pertaining to water quality are surfacing in the region, with evidence suggesting a strong nexus between groundwater quality and related health problems" (*Kulkarni et al, 2010*).

Groundwater usage – shift from community based dug wells to individual 'chapakals'

Historically, the entire populace of north Bihar used dug wells for sourcing groundwater. The entire social fabric was woven around the dug well. The community regularly cleaned and maintained dug wells. Various festivals were also based around the dug well. The dug well was a means towards interaction and bonding between people. With the advent of handpump technology in the early 1970's, certain key changes took place in the socio-economic setting of Bihar. People started moving from the community based dug wells towards private handpumps. This broke down the entire process of bonding which revolved around the dug wells. Handpumps (or 'chapakals' as they are known in local language) started turning out to be status symbols. Each household felt the need to have multiple chapakals. This also gave rise to a booming new industry – local

Photo 1: Rusted inner parts of a chapakals

manufacturers of chapakals. Local chapakals are cheap but there is also a big question mark over the materials used in the manufacturing. Opening of the headworks of chapakals often exposes rusty parts. However, with the rampant expansion of this industry, chapakals have become an integral part of north Bihar. The shift from dug wells to chapakals was initiated by convincing the people that dug wells are an unhealthy source of drinking water; being open to air, dug wells are often found to be littered with leaves and other materials. Similarly, dug wells tap the shallow aquifer and so the attenuation potential for microbes is low. This led to people relying completely on handpumps for drinking water. In some cases, dug wells were completely sealed off from the top to avoid any foreign materials from falling inside it and a handpump was inserted in the well to abstract water!

Effects of the privatisation of groundwater

Photo 2: Domestic sewage being discharged directly into a well

The spread of chapakals has led to the phenomenon, which can be termed as the privatisation of groundwater. It is the move from community-managed systems to a new individual ownership system. The most far-reaching effect of this act can be said to be the breakdown of the social fabric of rural north Bihar. Apart from this, the dug well, which was revered for centuries started being neglected and is being used as a hole for dumping wastes. The mental shift of the people has been so complete that toilets are being constructed over the dug wells. The social effects of this shift can be termed as indirect. Direct impacts are being observed in the form of water quality problems in large parts of north Bihar.

Floods – the background of this study

North Bihar periodically suffers from devastating floods. It stands out, as the single most important problem faced by the people and it is not surprising that most civil society organisations are working in this domain. However, Megh Pyne Abhiyaan selected only drinking water as the issue to focus upon. The reasons for this are multiple.

Drinking water is a problem for the people throughout the year - during and after floods. During floods, the chapakals are submerged under water or covered up in silt, thus creating a problem of access. People depend on extremely muddy river water or depend on external agencies to provide safe drinking water in the form of relief. Post monsoon, drinking water problems arise from a water quality perspective. Iron, arsenic and bacteriological contamination in groundwater is common-place in most north Bihar villages. Unsafe drinking water is linked to almost all the issues plaguing the people. People are spending hard-earned money on regular visits to the physician and on medications to treat ailments which arise mainly from unsafe drinking water. This is the money, which ideally would be used towards their economic upliftment. Constant health problems are causing reduced productivity which in turn is affecting livelihoods. It is very clear why drinking water is one of the most important issues linked to the development of rural people of north Bihar.

Various studies have been conducted to determine the genesis and occurrence of chemical contaminants in groundwater in alluvial regions. Arsenic has especially been studied in detail. However, very little is being done to provide practical solutions to the common man. Various filters have been tried for these contaminants, but the maintenance costs and dependence on materials not available locally prevents the spread of technology among the people.

Relief work is carried out on very large scales during floods. However, people are provided with bottled water to tide over the floods and then people revert to chapakals once the dry season sets in. This approach is based on providing a solution before trying to understand the problem. The effect of this practice is that people are losing the will to try solving any of their problems and instead depending on external agencies to provide relief.

THE APPROACH

The basis for selecting drinking water as the focal issue has been established in the above sections. The resource being tapped for drinking water needs is groundwater. It is a highly dynamic resource and many times acts as a source and sink concurrently. It acts as a sink for receiving the domestic sewage being generated in each household. This fact imposed the need to link sanitation to this study.
Having decided upon the issues; drinking water and sanitation, there was a need to understand the factors governing these problems. Both are invariably linked to groundwater and thus understanding this resource became a priority. The primary points to be considered in this aspect were –

- Dynamics of groundwater movement
- Groundwater quality issues
- The spatial and temporal variability of groundwater quality issues
- Establishing linkages among all of the above to provide alternatives for drinking water and sanitation at access and treatment level
- Providing flood resilient solutions
- Tying up of the entire methodology to a long term process at the community level

The objective of the study is to not only understand and provide solutions to the problems. One of the most significant aspects of this study is an attempt to establish a link between society and science.

METHODOLOGY

The dynamics of groundwater movement, the processes of recharge and discharge can be understood by monitoring variations in the water table. Water quality testing was carried out on selected sources (chapakals and dug wells) to assess the different kinds of problems and their spatial variability. Monitoring of groundwater levels is achieved by measuring the water levels in wells and handpumps from mean sea level. However, the selected study areas had very few dug wells and thus data had to be generated from handpumps. This was an extremely tedious and time consuming task as it entails the opening of the headworks of the chapakals to measure the static water level. Chapakals and dug wells were identified for regular monitoring. Water quality tests were performed for 12 parameters at all the selected sources. ACWADAM collected one time water level data from representative samples of all the 5 districts. The idea was to create an understanding of the entire process to be followed in a scaled up model. MPA staff carried out water testing using test kits. Some samples were also sent for testing in an educational institute. ACWADAM carried out *in situ* water quality tests using a hand held tracer for 5 parameters. Apart from the modern methods, a traditional method for detecting iron in water became apparent while interacting with the locals. In this method, fresh crushed guava leaves impart shades of purple colour to the water. Darker the colouring, higher is the iron content in water.

Study area

Megh Pyne Abhiyaan is a group of 5 organisations working in 5 different districts of north Bihar; Khagaria, Madhuwani, Paschim Champaran, Saharsa, and Supaul. All the selected districts are affected by floods and face the challenges that have been defined as the focal issues to be tackled in this study. Within each district 5 panchayats were selected for the study (Only 2 panchayats were selected in Paschim Champaran)

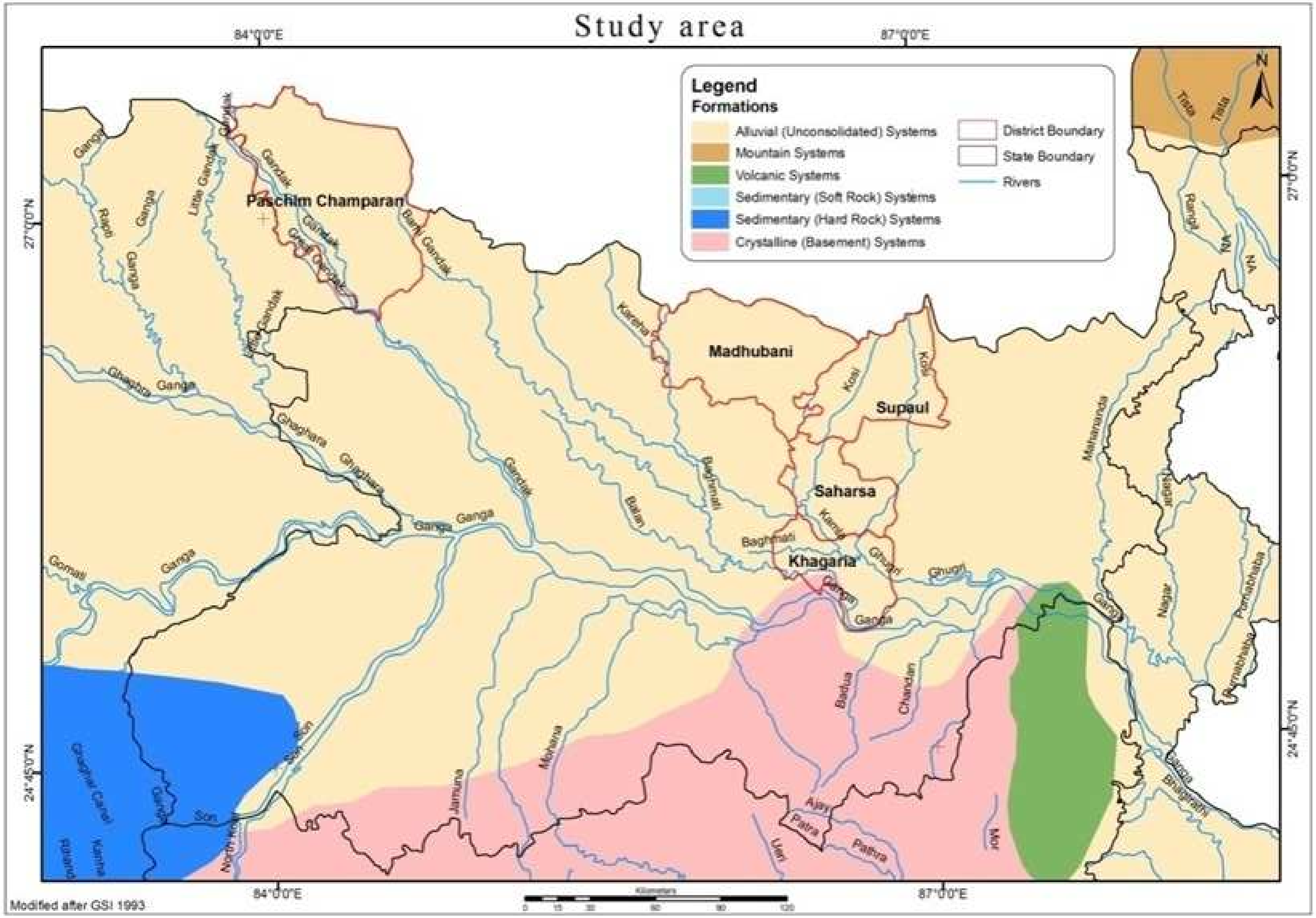
Khagaria	**Madhuwani**	**Paschim Champran**	**Saharsa**	**Supaul**
Bandh Chatar	Balia	South Telhua	Pastwar	Ghuran
Uttar Marar	Lakhnour	Shyampur Kotraha	Mahishi North	Bairia
Dahma Khairi Khutha	Gangapur		Mahiserho	Ramdattpatti
Madarpur	Hardi		Telher	Piprakhurd
Sarsawa	Harna		Maheshi South	Balawa

Table 1: District wise list of selected panchayats

GEOLOGY

North Bihar consists mainly of a thick sequence of alluvial deposits. The sediments brought down from the Himalayas since the beginning of their uplift by the large rivers were deposited in the plain regions at the base of the Himalayas in a NW-SE

Overlay of the selected districts on the broad hydrogeological typologies



direction. The thickness of these deposits in these regions is quite huge and the basement to these alluvial deposits rarely plays a role in the hydrogeology of the region.

The alluvium in North Bihar has been deposited over the years by the various rivers originating in the Nepal Himalayas, flowing into Bihar and then joining the river Ganga. The alluvium mainly consists of alternating sequences of sand and silt with abundant intermittent clay layers. In a few cases in the district bordering Nepal a few Terrai sediments also are found which are composed principally of boulder beds.

Overbank sedimentation is common to the region. This implies sediments deposited during and after the flood episodes during which riverbanks overflow and there is progressive building up of the banks. This is especially important in context to development of aquifer systems in the region. As Mahadevan (2002) sums up in his narrative: "...the Gandak-Kosi interfluve region exhibits a fining upward grain size distribution bottoming in sand or silt and interleaved with beds of coarse silt and sand; sediments show post-pedogenic alterations including decomposition of plant and shell material, carbonate dissolution and precipitation (iron oxide/hydroxide), accumulation and illuviation of clays". Such sediments usually constitute the host-regime for groundwater accumulation and movement and aquifers are developed as a consequence of the geometry of overbank deposits. An understanding of such deposits becomes important in understanding groundwater accumulation, movement and quality, especially in context to the small and large habitations located in the region (Kulkarni et al, 2009).

HYDROGEOLOGY

The groundwater in such geological formations occurs within the intergranular spaces. These are the spaces present between two grains of the formation and hence provide space for the storage of water within them. The interconnectivity between these pores gives rise to the permeability through which the transmission of groundwater occurs. The pore size and interconnectivity varies with the change in the size of the individual grains in the geological formation. The movement of groundwater in alluvial aquifers can be very slow due to the high storage factor and the small pore spaces. This in effect means that the storage in alluvial aquifers is much larger than the annual flow of water from it. The size of alluvial aquifers is generally very large. They can span huge areas cutting across many administrative areas. Alluvial aquifers can be continuously exploited and even if the abstraction rates outpace the recharge rates, the ill effects take long time to manifest themselves. This is due to the large storage factors involved. However, such practices are causing water quality issues to rise in alluvial aquifers. The issue of quantity does not crop up very quickly, but once depleted, recharging alluvial aquifers to normal levels may seem almost impossible.

OBSERVATIONS AND INFERENCES

Water levels and hydrogeology

ACWADAM collected water levels during their numerous visits to the study area. Along with the water level from the surface, the elevation and the geographic location was noted for each water source. The water levels were reduced from the elevations and were plot as water table contours. This exercise helped in visualising the movement of groundwater in the selected areas. Movement of groundwater generally follows the topography. However, it was observed that in spite of the extremely low gradient of these areas, there is a clear pattern to movement of groundwater, which does not follow the topography in most cases. Although it could not be verified, depths of chapakals were noted by interacting with the villagers.

The water levels were notably higher than the levels at which water was struck. This indicated the presence of confinement in the aquifers. It is important to note that this confinement is not at great depths. The presence of clay and fine silt layers between the sand and silt layers may be contributing to the confinement in the aquifers. The lateral continuity of these clay layers can be confirmed after detailed field investigations, which would enable in finding whether these are local features or have a regional extent. As this particular geology is formed due to the repetitive flooding and deposition by the rivers, there is bound to be a repetition in the sequence of the layers as well. This would lead to the formation of multiple confined or semi-confined aquifers. Confinement will also have a significant effect on the recharge by fresh water to the aquifers.

The low gradient of the area is not favourable for the formation of streams. Therefore, most water, which falls on the surface would infiltrate; but, how much of it contributes to the aquifers is a question which needs to be answered. The movement of groundwater in alluvial aquifers is very slow and the volumes stored are very large. The presence of confined aquifers relatively close to the surface further complicates matters. Thus, dilution of aquifers due to infiltration seems difficult in the existing conditions in North Bihar.

Water quality

- *Coliforms*

MPA conducted water quality tests over a period of 3 years. This included water quality testing using field test kits for 12 different parameters. As a part of the initial study to establish the problem areas and provide scientific reasoning to the issues, ACWADAM conducted detailed analysis of this data for 3 main parameters; iron, arsenic and coliforms. Iron and arsenic are geogenic contaminants while the presence of coliforms in groundwater is due to anthropogenic activities. Bacterial numbers are low in groundwater and sediments and decrease with depth (Beloin et al., 1988: Bone and Balkwill, 1988: Colwell, 1989). The presence of bacteria in open dug wells is not surprising. It could have fallen in with leaves, dirt or due to improper sanitation practices. However, the presence of bacteria in chapakal water is a worrying finding. 34% of the total chapakals selected for testing detected positive for presence of coliforms. World Health Organization guideline values for verification of microbial activity states that “*for all water directly intended for drinking, E. Coli must* *not be detected in any 100 ml sample*.” Almost all the dug well samples tested positive for presence of coliforms.

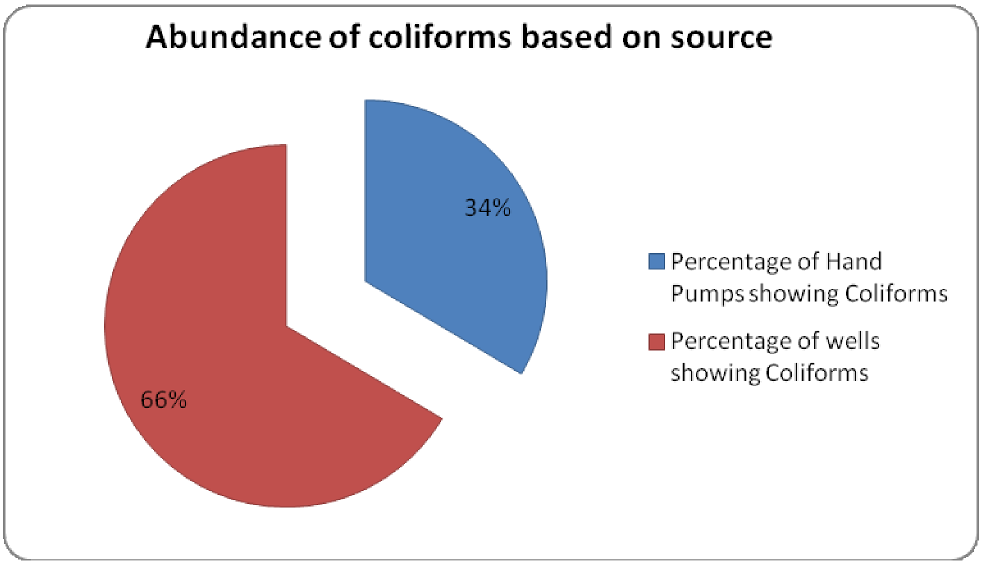


Figure 1: Abundance of coliforms based on the source

The reduction in bacteria with increasing depths of alluvium can be linked to the slow movement of groundwater. Therefore, chapakal water should ideally be devoid of coliforms. Indeed that was the reason for the propagation of chapakals in contrast to dug wells. The presence of bacteria can be due to the extremely poor sanitation practices followed by the locals. Similarly, the chapakals are more often than not surrounded by stagnant water and dead and decaying material. The effect is compounded by the inferior quality of headworks which help in carrying the contaminants directly to the aquifers. These contaminants would have passed through various layers of sand, silt and clay which would have acted as natural filters.

- *Iron and Arsenic*

In figure 2, the data from all panchayats in 4 districts has been plotted to display the distribution of iron concentrations in groundwater. The WHO has set 0.1 mg/L as the safe limit for Iron in drinking water. Figure 2 helps in bringing out the wide spread distribution of the iron problem in all the panchayats of all the districts. However, it also shows that there is no constant trend in the distribution. The problem is location specific and since it is related to groundwater, the distribution will depend on factors closely related to the occurrence and movement of groundwater. It is also evident that the variability at the panchayat level will not be clear if the approach had been to carry out the study at any other scale; block or district.

Figure 3 also shows the widespread nature of the problem. It signifies that the extent of iron contamination is far greater than has been documented. Almost 74% of the total checked samples contained iron concentrations higher than 1ppm which is far greater than the 0.1ppm safe limit.

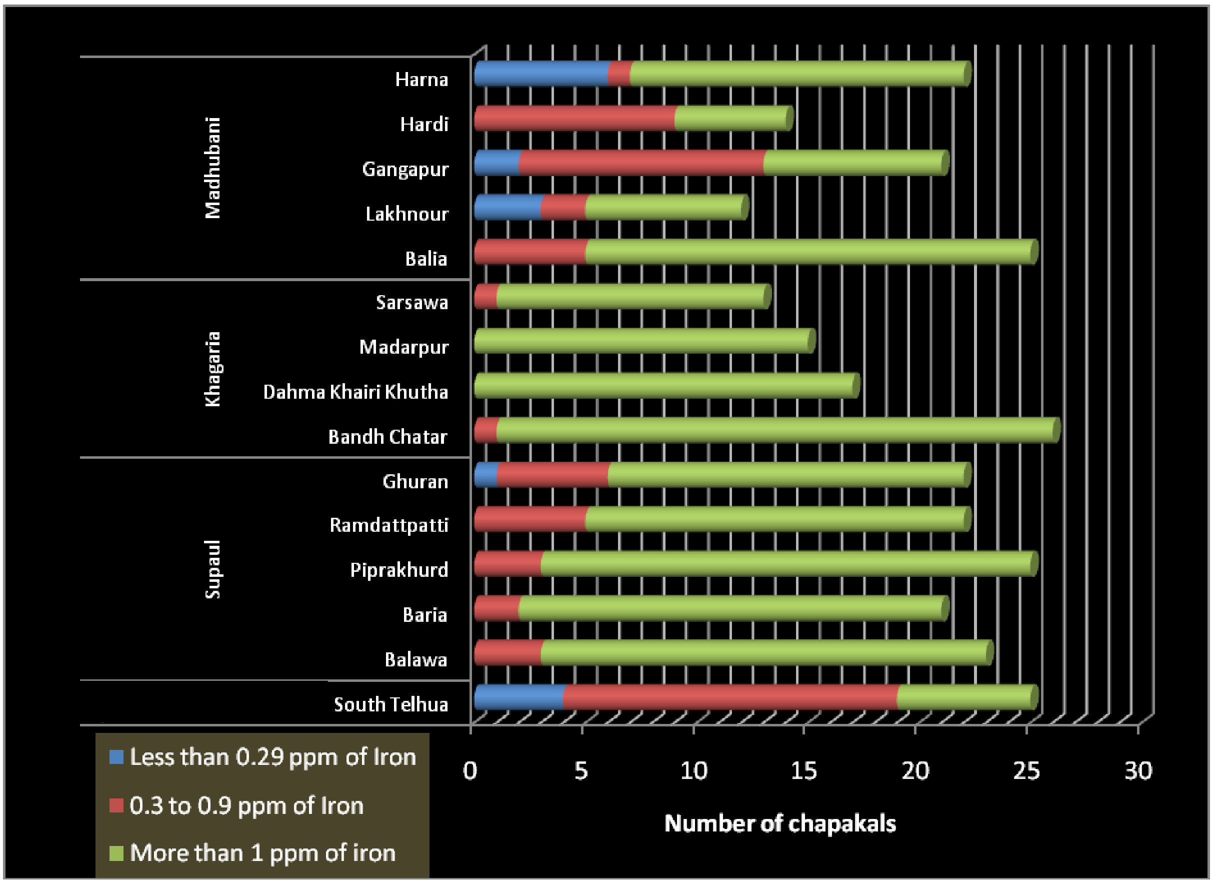


Figure 2: Distribution of iron concentrations in chapakals (2008)

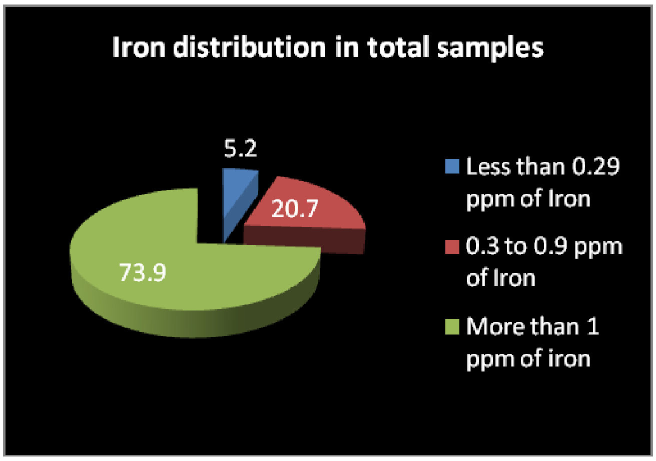


Figure 3: Distribution of iron in total samples

Another significant finding from the water quality tests has been that almost none of the sampled dug wells contained iron. Chapakals and dug wells, which were in very close proximity of each other and tap similar aquifers, also confirmed the same trend.

In natural low oxygen conditions, iron is present in water in the form of ferrous ions (Fe^{2+}). Ferrous ions are unstable and when exposed to oxygen, they form ferric ions (Fe^{3+}). Ferric in turn forms oxides and hydroxides, which are insoluble in water. The pH of groundwater in the study area ranges between 7 to 8.5. This range is suitable for the conversion of ferrous to ferric in the presence of oxygen. Thus, the open dug wells, which are constantly aerated at the surface, are devoid of dissolved iron. Insoluble oxides and hydroxides of iron settle at the bottom of the well and need to be cleaned out periodically. Water quality tests conducted on samples collected from the bottom of a dug well showed the presence of iron. This endorses the theory that iron is being oxidised and deposited at the bottom of a dug well. Chapakals tap deeper aquifers which are confined or semi-confined. Thus the oxygen levels are very low enabling the ferrous ions to remain dissolved in water.

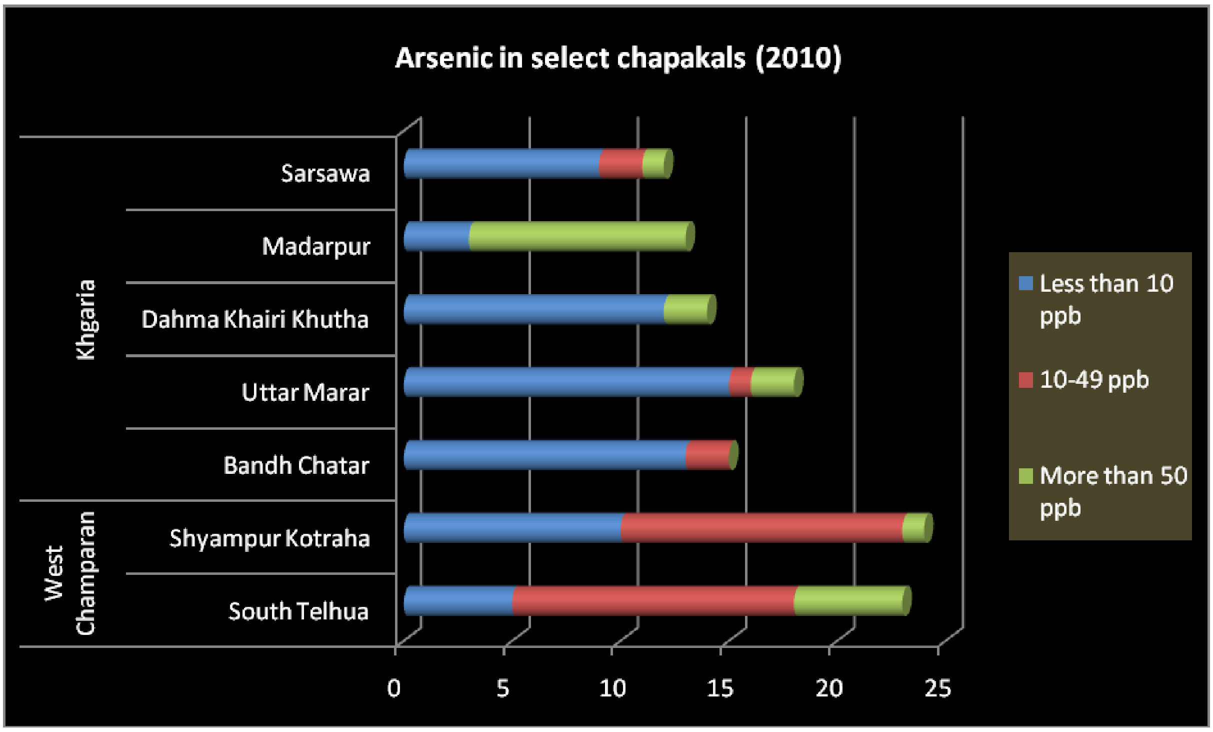


Figure 4: Distribution of arsenic

The distribution of arsenic in chapakals has been displayed in figure 4. The WHO limit for Arsenic in water is less than 10 ppb. As in the case of iron, arsenic problem is also much more wide spread and variable from location to location. It has also been observed that those sources that show very high concentrations of iron tend to have higher concentrations of arsenic. This indicates some relation between the 2 contaminants. Similarly, arsenic is not observed in dug well waters. The ability of iron oxides and hydroxides to adsorb arsenic ions may be responsible for the removal of dissolved arsenic from open dug wells.

SUMMARY

From the limited initial water quality data, an inference that reducing conditions dominate in most chapakals can be easily drawn. On the other hand, dug wells, being open to air, enable natural oxidation processes. Chapakals were introduced in the area because dug wells are susceptible to bacteriological contamination and water at depths is considered to be free from these contaminants; also, chapakals implied improved access to water at the household level. However, geogenic chemical contaminants like iron and arsenic can be very difficult to treat. The cost of filters and the recurring costs of renewal of the filter media can be major deterrents to the acceptance of such treatment options. On the other side, dug wells have emerged as a safe alternative to chapakals. Dug wells are open and are at a risk from biological contamination. Nevertheless it is much easier to treat (and avoid to certain extents) than chemical contamination.

The background to this entire study was the context of floods and therefore, the dug well design had to be flood resilient. Simple modifications in the design like increased wall height from the ground surface, locally sourced bamboo covers to avoid unwanted substances from falling into the well, proper drainage systems around the well to carry away used water and so on aid in reducing the risks to this traditional system from floods and bacteriological contamination. The process of cleaning, repairing and maintenance of the dug well has to be shouldered by the local populace which acts as an added benefit leading to bonding amongst the community. Apart from all the above precautions, dug wells can also be regularly disinfected using one the many inexpensive treatments available.

Dug wells are a feasible option in the dry seasons. However, drinking water becomes a major problem for people living inside the embankments. Access to any source of drinking water becomes very difficult and rainwater harvesting provides the alternative in this case. MPA has propagated very simple models which use minimum resources and can be created by using readily available local materials for temporary rainwater harvesting during floods. Post floods, MPA is also trying to provide rainwater storage solutions in a similar manner. Local materials are used by local potters to create ‘Jal kothis’ which will store rainwater for long durations.

Using the same concept of local material and local labour, MPA is also trying to spread the use of ‘Matka Filters’ which are used for treatment of bacteriological and iron contamination.

The data that has been analysed points to the facts that the problems vary from location to location. The general methodology remains the same; however it is essential to understand the local hydrogeological factors before arriving at solutions for an area. The demarcation of recharge and discharge areas can aid in locating broad areas for community dug wells. Discharge areas are where water comes in from all directions, thus there is a dilution of groundwater. Therefore, such areas are ideal for a dug well.

To sum it up, the approach to the drinking water problems of North Bihar needs to be targeted at two levels, at the resource level and at the treatment level. Such an approach is possible only if the resource is considered a “commons”, a fact once accepted by the community, paves the way for a systematic system of responses and processes that can overcome the challenges in water supply sustainability in flood affected Bihar. Viable solutions evolve as a consequence of a community based effort in dealing with water. Understanding the resource – groundwater, in this case - becomes imperative and the study has to be from village level upwards. The exact conditions in each village will be unique and the responses to those conditions cannot be generalised at any other scale.

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