Changing the lives of the rural community of Bihar through Multi-Village Piped Water Supply Schemes by Public Health Engineering Department (PHED)

A Case Study on the impact of Multi-Village Schemes (MVS) for Piped Water Supply in Bihar

WASH Observatory

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The sight of flowing water from the mouth of the tap brings a twinkle in the eyes of Geeta Devi, a woman who has spent half her life, trudging arduous journeys over vast stretches in the quest for water. Until 2019, the residents of the Rajauli block of Nawada district survived on water collected from wells and public standposts, where they squandered away their precious time, spending long hours in the queue, waiting for their turn while a major part of their livelihood ventures and leisure time was lost. Hardiya Panchayat of Rajauli block in Nawada district is affected by high fluoride concentrations of 3.5 mg/l (more than 1 mg/l- acceptable limit) in groundwater. Around a decade ago, vulnerable population groups and children of the region were affected by dental and skeletal fluorosis, a crippling disease due to dependence on groundwater for drinking water purposes. What the people needed to fight fluorosis was access to safe drinking water. The efforts of the government to provide safe fluoride-free water gathered momentum which culminated in the installation of multi village piped water supply schemes based on the provision of surface water, mainly from Phulwariya dam since 2019 to the district. The reservoir provides water that has permissible limits of fluoride which has helped deal with the vital public health issue arising out of drinking fluoride contaminated water. Says a happy Geeta Devi, recounting the old perilous days when individuals with ruptured bone structures and crippled youngsters with yellow and stained teeth were a common sight, "such deformities are rarely visible today".

In Bihar**,** 89% of the population lives in rural areas and as per NSS 2018 report, 97.2% population depend upon groundwater extracted through handpumps and tube wells, for drinking water supply. A study conducted by the state government on fifteen parameters to check groundwater quality in 2002-03 brought into light the contamination of water with fluoride and iron in various parts of Bihar. In 2002, two villages,
Barisban and Semaria Ojhapatti, in Bhojpur district, located in the western part of the Bihar state, were reported to have arsenic contamination exceeding 50µg/L.

The water quality mapping of Bihar initiated by the state government in November 2007 - February 2008 under which 226145 samples were tested covering all the 38 districts, indicated the poor quality of water in rural areas emerging as a

grave threat to the health of the rural population.[1] As reported by PHED Bihar, at present, 14 districts in Bihar are Arsenic affected, 11 fluoride affected and 11 are iron prevalent districts. Apart from chemical impurities, fecal contamination of water is prevalent in many water sources (Envirotech Report 2008).

It has been found in Arsenic affected areas that the water of open wells is safer in respect of Arsenic. The deep tubewells (Depth >125M) are yielding Arsenic-free water whereas in fluoride-affected areas the fluoride content is increasing with depth. Two districts, Munger and Bhagalpur have been found to be contaminated with iron, arsenic and fluoride. Studies in several districts of north plains, viz. Patna, Bhojpur, Vaishali, and Bhagalpur have indicated substantial arsenic content in groundwater attributed mainly to overexploitation of groundwater.[2]

Quality Affected districts in Bihar		
14 Arsenic Prevalence Districts	11 Fluoride Prevalence Districts	11 Iron Prevalence Districts
Saran	Kaimur	Supaul
Vaishali	Rohtas	Araria
Samastipur	Aurangabad	Kishanganj
Darbhanga	Gaya	Saharsa
Buxar	Nalanda	Purnea
Bhojpur	Shiekhpura	Katihar
Patna	Jamui	Madhepura
Begusarai	Banka	Begusarai
Khagaria	Munger	Khagaria
Lakhisarai	Bhagalpur	Bhagalpur
Munger	Nawada	Munger
Bhagalpur		
Katihar		
Sitamarhi		

MITIGATION AND REMEDIATION INITIATIVES OF THE GOVERNMENT

Alternate planning and management of water resources to be adopted in the affected and vulnerable areas and availability of safe drinking water has always been at the forefront of the government agenda. Amongst the various states in the country, the Census 2011 shows very low coverage in terms of tap water connection in eight low-income states with Bihar (2.6%), Jharkhand (3.7%), and Assam (6.8%) being the lowest in comparison to other States in India.

In this context, the then Ministry of Drinking Water and Sanitation (MoDWS), GOI, prioritized these four states for the implementation of a Rural Water Supply and Sanitation Project for Low Income States (RWSS-LIS) in the first phase under the title of Neer Nirmal Pariyojna. In Bihar, the PHED identified 10 districts that were initially selected to be covered under the RWSS-LIS Project based on the following broad criteria: districts with low coverage of piped water supply and sanitation within the state, quality affected districts especially with chemical contamination (Fluoride,

[1] *https://wedc-knowledge.lboro.ac.uk/resources/conference/34/Mishra_D_S_-_202.pdf, accessed on August 20, 2021 at 03:41pm*
[2] *https://www.researchgate.net/profile/Santosh-Nepal-2/publication/326199339_Groundwater_Dynamics_in_North_Bihar_Plains/links/5b3db899aca272078511a8f5/Groundwater-Dynamics-in-North-Bihar-Plains.pdf, accessed on August 20, 2021 at 03:47pm*

Arsenic, and Iron) in groundwater, districts with a large number of water-scarce habitations, districts with large socially and economically disadvantaged population**,** districts where sustainable water sources are available, yet the coverage is low.[3] These Districts are namely Nalanda, Patna, Saran, Munger, Begusarai, West Champaran, Muzaffarpur, Banka, Nawada, and Purnia. Later, the list of intervention areas was expanded to include four more districts.

To address the need for clean and safe drinking water in rural Bihar, Mukhyamantri Gramin Peyjal Nishchay Yojana (MGPNY), one of the four components of the Har Ghar Nal Ka Jal scheme (HGNKJ) w as launched in September 2016 to provide for 70 lpcd of clean and safe drinking water to every citizen in Bihar by connecting all households with a functional piped water connection. The schemes which have been taken up under the HGNKJ to be implemented by the Public Health Engineering Department PHED include: Multi village piped water scheme (MVS), Single village Piped Water scheme, and ward-based scheme. The key issues that are supposed to be addressed by the HGNKJ scheme include among other things, inadequate or disrupted water supply, bacteriological contamination of surface and groundwater, and the presence of fluoride/arsenic/nitrate/iron concentrations exceeding the permissible levels in drinking water.

There is a total of 8396 gram panchayats and 1,14,691 wards in Bihar. Under the MGPNY, the Public Health Engineering Department (PHED) has been assigned the responsibility to provide household tap water connection in 56,544 wards out of which 30,272 wards are quality affected and 26,272 are non-quality affected. The remaining wards are to be covered through the Panchayati Raj Department (PRD). Till February 2021, piped water scheme has been completed in 1,09,463 wards and approximately 1.47 crore families have been provided Nal Ka Jal.

The government of Bihar, through the PHED, has already taken significant steps to meet the challenges arising out of groundwater contamination, poor water quality, and providing potable water in quality affected areas. As a part of the various corrective and precautionary measures leading to mitigation and remediation of the issues emerging out of groundwater contamination and anticipated depletion in Bihar, development of surface water-based multi village water supply schemes (MVS) to provide regular and safe water in many arsenic, fluoride, and iron-affected areas can be counted as one of the major achievements of the PHED. Supply of surface water from dams, lakes, rivers, etc. for drinking purposes through pipe network system after suitable purification by the modern method of treatment as an alternate option, have been put into practice in some places by the state government. As many as 14 MVS have been operationalized by the state government in Bihar to date.

SCHEME DETAILS	DISTRICT
1. Maujampur MVS	BHOJPUR
2. Khaira MVS	MUNGER
3. Silao MVS	NALANADA
4. Rajauli MVS	NAWADA
5. Cheria MVS	BEGUSARAI
6. Kahalgaon - Pirpainti MVS	BHAGALPUR
7. Bidupur MVS	VAISHALI
8. Maner MVS	PATNA
9. Matihani MVS	BEGUSARAI
10. Sultanganj - Nathnagar MVS	BHAGALPUR
11. Silao MVS Phase 2	NALANDA
12. Budhauli Bankar MVS	LAKHISARAI
13. Simari MVS	BUXAR
14. Ghoghaghat, MVS	BETTIAH

[3] *https://www.bswsmpatna.org/spmu.html, accessed on August 21, 2021 at 01:46pm*

MULTI VILLAGE SCHEMES (MVS) IN BIHAR

The department has identified the key issues facing the sector and has made a consistent effort towards meeting the existing constraints in the use of groundwater for drinking and domestic purposes through the implementation of MVS. The prime motivation for setting up multi village schemes is based on the desire to provide full water supply coverage to rural areas despite local water scarcity and contamination of sources. However, treating and piping water from remote sources is often complex and expensive, and it is felt that the cost of supply can be reduced and options broadened if several villages are served by one scheme. Multi village water supply schemes are assuming greater significance due to their potential to capture economies of scale and to facilitate higher levels of service, and appear to offer a feasible and long-term solution to the acute water scarcity faced by many regions.[4]

The multi-village schemes which formed the area of our study comprised of three major components: the source of water supply, treatment of the water, and the distribution of water to the users. The source water varied across different MVS. The Ganga river is a source of water for Kahalgaon-Pirpaiti and Maujampur MVS, Budhi Gandak for Cheria MVS, Phulwariya dam for Rajauli MVS, and Kharagpur lake for Khaira MVS. Many research papers suggest that a surface water-based multi-village scheme is one of the best options for drinking water supply schemes.

The essential elements of a water treatment plant (WTP) are a pre-settling tank, cascade aerator, flash mixture, clarifloculator, filtration, clear water sump, pump house, master elevated service reservoir, and service reservoir. Centrifuge unit and SCADA room were also observed as a part of the WTP in some of the MVS. An in-house laboratory of the WTP functioned as a well-equipped centre for the testing of basic water quality parameters to ensure the delivery of desired quality of treated water. The capacity of elements varied as per the capacity of the WTP.

The source water is first collected to a pre-settling tank (PST) to allow much of the sand and debris to naturally settle out of the water before it is pumped for further processing. Cascade aerator receives water from the PST. The aerator is designed to trap oxygen from the air to increase the percentage of dissolved oxygen in the water so that foul gases are extracted. Raw water with enriched oxygen content then moves to the flash mixer, where alum/lime is added to maintain turbidity at the desired level.

Water then passes to clarifloculator after the flash mixture for flocculation which is a slow stirring process that causes the small coagulated particles to form floc. The floc formed creates a surface in which the particulates in the water adsorb (adhere) to the surface of the floc thus forming larger settleable particles for ease of removal by sedimentation and filtration. From the clarifloculator, water moves to quicksand filter beds. The bottom of each bed contains layers of sand, gravel, and perforated pipes at the bottom, for collecting filtered water after being percolated through layers of sand particles and gravels. From the filter beds, the filtered water moves to a control chamber and then through a filter water channel to a chlorine contact tank (CCT), where it is disinfected before being supplied to villages. The water is pumped to a master elevated service reservoir (MSER) WTP campus for storage and distribution of water directly to the villages

[4] *http://www.indiaenvironmentportal.org.in/files/multivillage.pdf, accessed on August 23, 2021 at 09:29pm*

or through elevated service reservoirs located in different zones. The role of Pump operators at the ESR was seen as very crucial in maintaining the regularity and punctuality in the water supply and as the first point of contact for grievance redressal where the SCADA system was not applied. Cheria MVS was equipped with SCADA system for controlling most of the units of the WTP. All the MVS were based on a zero-waste approach.

USE OF SURFACE WATER SOURCES IN MVS

Varieties of conventional arsenic/fluoride/iron removal plants developed for the treatment of quality affected water suffer from operational and maintenance challenges and sludge disposal problems. Moreover, in the absence of adequate and in-built maintenance arrangements, the performance of all the
devices would be compromised. In this scenario, the best remedial and corrective option has been provided in the form of a surface water source-based multi village scheme, considering its high-level service delivery prospects and advanced technology with the provision of highly equipped chemical treatment facilities.

Most of the MVSs are based on surface water sources for intake of water and it has been reported that surface water is less contaminated as compared to groundwater in quality-affected areas. The PHED has conducted water quality testing of groundwater, source water, and treated water of the five MVS under study which validates this contamination issue. The water quality test reports are illustrated in the table below.

Water Quality test report of the surface water based MVS

Sl No.	Quality Parameters	Unit	Requirement (Acceptable Limit)	Permissible Limit (in the absence of Alternate Sources)	Rajauli MVS			Mauzampur MVS			Cheria MVS			Khaira MVS			Kahalgaon Pirpainti MVS		
					Ground Water	Source water/ Inlet water	Treated water	Ground Water	Source water/ Inlet water	Treated water	Ground Water	Source water/ Inlet water	Treated water	Ground Water	Source water/ Inlet water	Treated water	Ground Water	Source water/ Inlet water	Treated water
1	Colour	Hazen	5	15	3	13	1												
2	Turbidity	NTU	1	5	3.4	12	0.87	3	80	2	4	6	BDL	1	25	0.5	1.26	445	0.9
3	pH	.....	6.5 – 8.5		6.89	7.91	7.89	7.41	7.31	7.23	7.9	7.9	7.5	7.17	7	7	7.23	8.02	7.7
4	T.D.S	mg/lit	500	2000	243	83	84	230	235	241	2600	125	132	811	90	120	524	142	148
5	E. Conductivity	µ mho	-----	-----	488	166	168	351	351	366	4000	192	203				1004	230	232
6	Total Alkalinity	mg/lit	200	600	244	86	80	184	158	170	320	272	268	496	22	25	162	100	94
7	Total Hardness	mg/lit	200	600	348	78	78	160	142	150	298	268	264	460	45	50	242	92	88
8	Calcium Hardness	mg/lit	75	200	36.87	19.23	14.24	40	38	42	112	55	75	144	20	28	86	20	42
9	Magnesium Hardness	mg/lit	30	100	10.6	6.24	6.24	14	14	15	19	17	17	24	25	22	21.3	4.92	4.7
10	Chloride	mg/lit	250	1000	30	18	18	22	20	24	1730	68	63	150	12	10	44	10	12
11	Arsenic (As)	mg/lit	0.01	No relaxation	----	----	----	0.013	BDL	BDL	BDL	BDL	BDL	NIL	0.002	0.003	0.015	BDL	BDL
12	Iron(as Fe)	mg/lit	1	No relaxation	0.1	0.06	0.01	0.63	0.21	0.14	0.79	0.63	0.16	0.2	NIL	NIL	1.18	0.13	0.12
13	Nitrate (NO3)	mg/lit	45	No relaxation	9.2	37.5	6.2							0	5	2	6.24	4.36	3.47
14	Sulphate(as SO4)	mg/lit	200	400	38	13	9				42	NT	NT	100	5	15	10	5	5
15	Fluoride(as F)	mg/lit	1	1.5	3.5	0.6	0.2	0.13	0.16	0.11	0.63	0.65	0.61	2.7	0.02	NIL	0.24	0.18	0.16
16	E. Coli	MPN/100ml	.....	.....	3	460	Nil							0	0	0			
Date of Sample Collection					26.07.21	26.07.21	26.07.21	28.07.21	17.06.21	17.06.21	20.07.21	20.07.21	20.07.21	22.06.21	22.06.21	22.06.21	05.02.21	21.07.21	21.07.21
Date of Report generation					27.07.21	27.07.21	27.07.21	05.08.21	18.06.21	18.06.21	22.07.21	22.07.21	22.07.21	25.06.21	25.06.21	25.06.21	10.02.21	23.07.21	23.07.21

Figure 1: Water quality test report

An analysis of groundwater dynamics in the plains of Bihar using 30 years (1983-2013) of groundwater level data reveals a 2-3 m decline in groundwater level in several districts such as Bhagalpur, Samastipur, Begusarai, Katihar, and Purnea in both pre-monsoon and post-monsoon periods in 2004-13. Similar depletion in groundwater storage can be observed in Samastipur and Purnea districts which are indicative of an alarming trend of water scarcity in these areas.[5] As a consequence of the declining trends of groundwater level, groundwater quality is also deteriorating. Groundwater in Bihar shows the presence of unhealthy levels of fluoride, arsenic, and iron making the control of drinking-water quality critical in the prevention of diseases.

[5] *https://www.researchgate.net/publication/326199339_Groundwater_Dynamics_in_North_Bihar_Plains, accessed on August 20, 2021 at 03:41pm*

A research study on "Can climate change cause groundwater scarcity in Bihar" done by Micro Insurance Academy, New Delhi, India, and Erasmus University Rotterdam, Institute of Health Policy & Management, Netherlands indicates that a water-rich State like Bihar can face groundwater scarcity for human use in the medium and long term. Climate change and Population growth can reduce the per capita availability of groundwater for domestic use in Bihar by as much as 15.9% by 2021 and by 44.9% by 2051.[6] With groundwater conditions deteriorating day by day, the community is facing drinking water scarcity. Since water collection for domestic purposes is the prime responsibility of rural women, they had to trudge long distances to collect water from the dam and wells in the farmlands.

The arduous task of fetching drinking water from distant sources and being engaged in domestic chores like washing clothes and cooking used up a major part of the day of women, precluding them from engaging in livelihood activities

Figure 2: Kahalgaon-Pirpaiti MVS, Bhagalpur

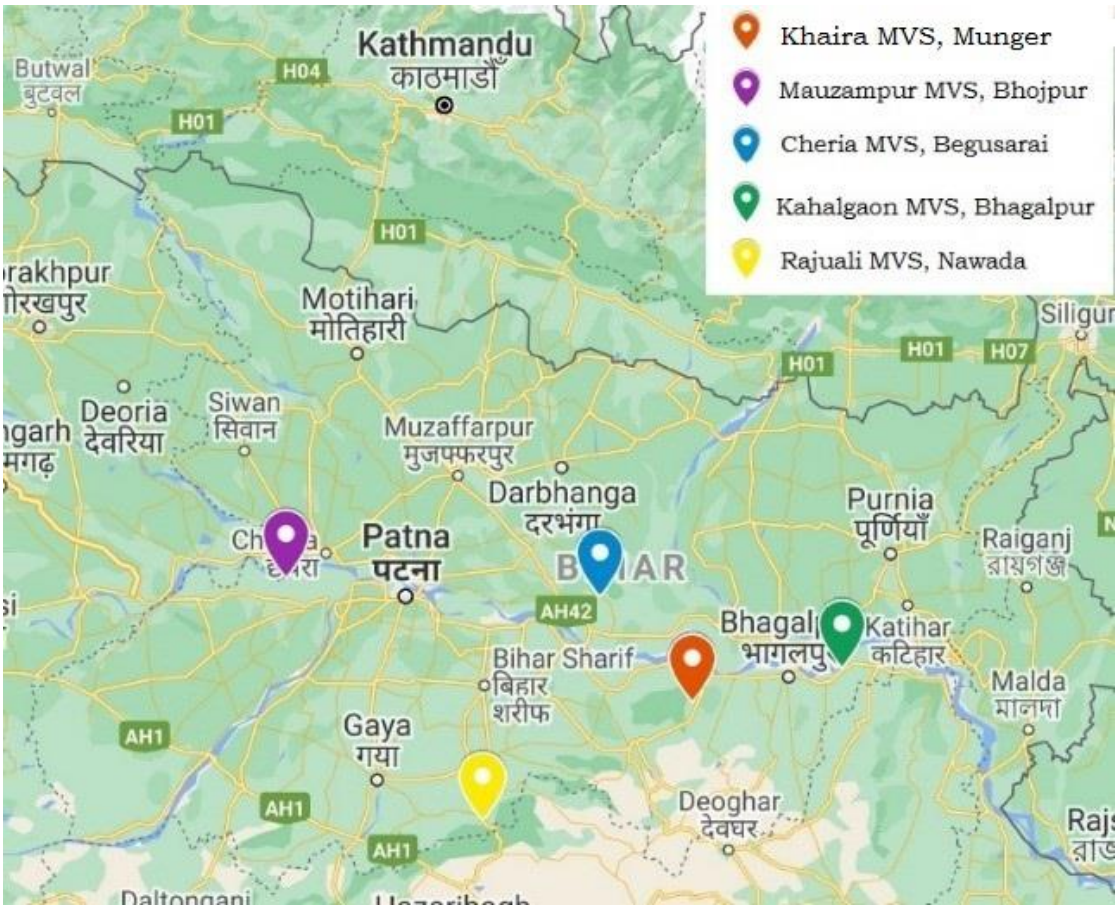
and affected educational opportunities of adolescent girls. Access to safely managed drinking water services was an essential step towards improving the living standards of the households and bringing about ease of living to the womenfolk living a life of drudgery.

Against this backdrop, the use of surface water sources in the MVS, as an alternate to the contaminated and depleting groundwater source has proved to be the best counteractive technological measure.

[6] *https://www.researchgate.net/profile/DavidDror/publication/272524851_Can_climate_change_cause_groundwater_scarcity_An_estimate_for_Bihar/links/59eb118c4585151983c80c69/Can-climate-change-cause-groundwater-scarcity-An-estimate-for-Bihar.pdf, accessed on August 22, 2021 at 11:16am*

PURPOSE OF THE CASE STUDY

To obtain an understanding of the advantages of surface water based MVSs and the concomitant socio-psychological and health impact upon the community, together with the challenges/constraints in the implementation of the scheme, a study was conducted by the WASH Observatory, Development Management Institute (DMI) in five selected districts of Bihar.



The objective of the case study was to document the best practices of the multi village piped water supply scheme with an overarching aim to provide an insight into the field level interventions, strengthening and modifications of techniques and activities based on learning experiences and reflection and review of how large scale, sustained and more successful interventions can be implemented.

METHODOLOGY

For this case study, the methodology comprised of a mix of tools with an emphasis on the multi village schemes operational in five quality affected districts of Bihar, especially those affected by arsenic, fluoride, and iron. The data was collected through Focus Group Discussions, semi-structured interviews as well as personal interaction with the male and female members of the community. Secondary data was provided by the PHED as the state agency responsible for the implementation of the schemes.

Field visit

The WASH Observatory team undertook a tour of six villages in the assigned districts where the surface water based MVS is operational(the dates and schedule of the tour is indicated in the table below).

S.No.	Location	Date of visit
1	Rajauli MVS, Nawada	13th-14th July 2021
2	Mauzampur MVS, Bhojpur	16th July 2021
3	Cheria MVS, Begusarai	23rd July 2021
4	Khaira MVS, Munger	27th-28th July 2021
5	Kahalgaon-Pirpaiti MVS, Bhagalpur	29-30th July 2021

Semi-structured interview

Semi-structured interviews were conducted with the state and district level functionaries, including the Executive Engineers, Assistant Engineers, Junior Engineers, and the staff of the agency for the implementation, O&M of the concerned MVS of the selected districts to obtain a comprehensive picture of the management of the scheme.

Focus group discussion (FGD)

The male and female members of the community were engaged in FGD to understand the issues related to the accessibility, availability, quantity, and quality of drinking water and to assess the impact of the piped water supply scheme on their lives.

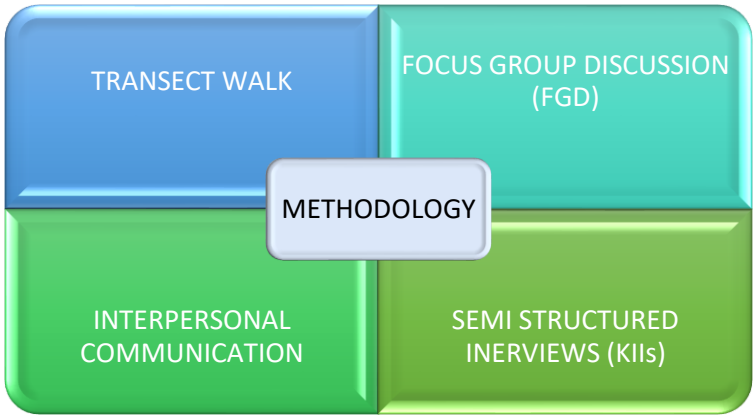
Figure 3: FGD with the female community member

Inter-Personal Communication (IPC)

An interaction was done with the community members selected on a random basis to triangulate the information collected. The community members shared their personal experiences and stories depicting the transformation in their lives with the provision of the tap water connection to their households.

Transect Walk

A systematic walk along the villages served by the MVS was undertaken as a participatory technique to interact with the community and ascertain the flow and accessibility of water in the villages to obtain an overview of the extension of functional household tap connection (FHTC) as envisaged by the HGNKJ scheme. Direct observation and informal communication with the onlookers and passers-by were done randomly to understand the community's perspective on the efficacy and importance of the scheme.



The team also visited the WTP for experiential learning about the treatment of raw water and components used in the plant and also to understand the details of the filtration process. The different units of the treatment plant were found to be fully functional and it was observed that clean water was being distributed through pipes before being delivered to the villages.

Health hazards of contaminated water

Contamination of drinking water can occur in the source water as well as in the distribution system after water treatment has already occurred. There are many sources of water contamination, including naturally occurring chemicals and minerals (for example, arsenic, fluoride, iron and nitrate), local land use practices (fertilizers, pesticides, concentrated feeding operations), manufacturing processes, and sewer overflows or wastewater releases. The presence of contaminants in water can lead to adverse health effects:

1. *Water borne diseases such as diarrhoea, cholera, typhoid due to bio contamination of surface water;*
2. *Vector-borne diseases such as malaria, dengue, etc. due to stagnant water*
3. *Diseases due to chemical contamination such as Arsenicosis, a type of skin cancer caused due to excess Arsenic, Fluorosis – skeletal/dental/non-skeletal caused due to excessive Fluoride etc.*

Groundwater in Bihar shows the presence of unhealthy level of fluoride, arsenic and iron. Intake of excess fluoride, commonly found in drinking-water, causes fluorosis which affects the teeth and bones. Moderate-level chronic exposure (above 1.5 mg/litre of water - the WHO guideline value for fluoride in water) which leads to dental effects is more common, but long-term ingestion of large amounts can lead to potentially severe skeletal problems. Dental fluorosis is characterized by staining and pitting of the teeth. In skeletal fluorosis, fluoride accumulates in the bone progressively over many years. The early symptoms of skeletal fluorosis, include stiffness and pain in the joints but over a long period of time, the bone structure may change and ligaments may calcify, with resulting impairment of muscles and pain. The control of drinking-water quality is therefore critical in preventing fluorosis.

Grave health effects are associated with the consumption of arsenic contaminated ground water like various types of skin manifestations and other arsenic toxicity can be observed from melanosis, keratosis, hyperkeratosis, dorsal keratosis, and non pitting edema to gangrene and cancer. Arsenic in water more than acceptable limit of 0.01 mg/litre is harmful and unfit for consumption for drinking and cooking. It is mainly found in deeper levels of groundwater. Besides, ingestion of arsenic through the food chain due to the use of arsenic contaminated groundwater for agricultural activities and the consumption of crops yielded from soil irrigated by such water adds to the health hazards in the affected areas. Arsenic exposure through food chain is observed not only in the contaminated areas but also in uncontaminated areas where the inhabitants may purchase those crops and consequently consume arsenic from the contaminated food.

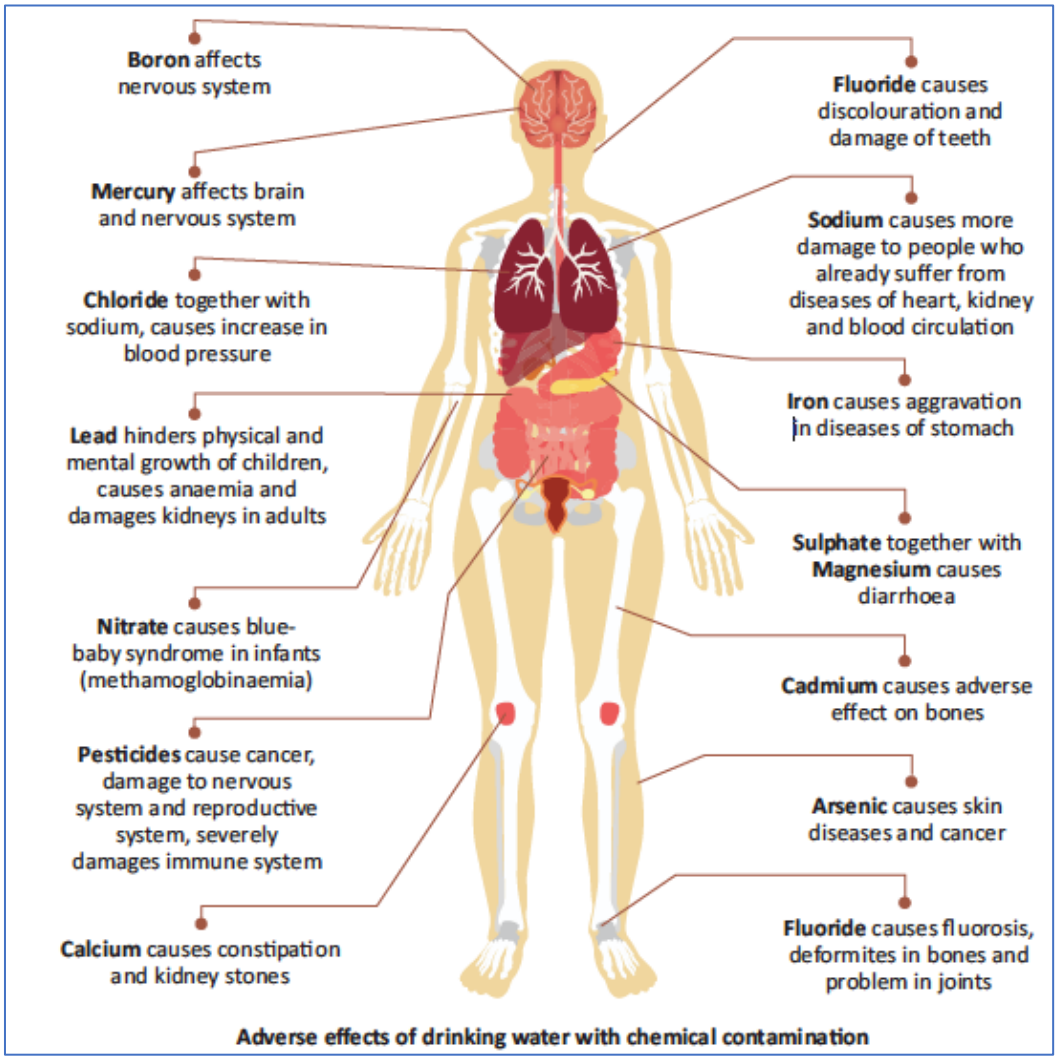


Figure 4: Source-National Jal Jeevan Mission Document

Water contaminated with high concentration of iron, more than the acceptable limit of 1.0mg/litre has affects human health, and if consumed on a long-term basis, may lead to aggravation in gastric-related issues, diabetes, hemochromatosis and can even damage the liver, pancreas, and heart.

Breaking the gender stereotype: Rubina Khatun, Pump Operator, Rajauli, Nawada

Stepping into the male bastion has been a cakewalk for Rubina Khatun, a young and vibrant 25-year old girl hailing from a remote village in Rajauli block of Nawada district. The coming of the MVS heralded a new career option for Rubina, a graduate in Geography, whose minority background in no way posed a hurdle in the pursuance of her aim. Rubina proudly claims to be the solitary female pump operator in the district.

Delicate, dainty hands wielding the heavy pump is a sight to behold. Says an excited Rubina recounting her daily routine, "I get up at six in the morning and rush to the pumphouse to release water from the pump. The happiness of the people waiting eagerly to start their daily chores with the supply of water gives me a sense of satisfaction in my job". Rubina is promptly at work, operating the pump from six to ten in the morning and one to three in the evening. This high-spirited girl has been associated with the community as a community mobilizer under the Neel Nirmal Pariyojana for five long years. "I attended Panchayat meetings and worked with Jeevika and other women's groups, mobilizing the community around water issues and improving community awareness about the need for clean drinking water to their health and standard of living," she shared.

Apart from her contribution towards advocacy and social mobilization, Rubina is adept at handling minor repair and leakage issues in the water supply system and maintaining records of the water flow meter. Although lamenting the community resistance and behaviour which run counter to project objectives by some beneficiaries who uproot and dislodge connections in schools and public places, she is satisfied with the behavioural change induced in the community at large. "Due to laying out of pipelines and other expansion activities, water supply is interrupted in the evening since the last two months. The community having got a taste of the ease of living with the access of safe drinking water to their households, is getting restless." This is an indicator of the genuine involvement of the community in these projects and their increased awareness level. Highly optimistic about the success of the water supply schemes, Rubina firmly believes that women's role in the water sector needs to be strengthened with their increased involvement in the operation and management since there has been a long-standing relationship between women and water since times immemorial and it is "women who understand water issues better than their male counterparts."

A PROFILE OF THE MVSs UNDER STUDY

The five Multi-Village Schemes - Kahalgaon-Pirpainti MVS in Bhagalpur, Khaira MVS in Munger, Mauzampur MVS in Bhojpur, Cheria MVS in Begusarai, and Rajauli MVS in Nawada were selected as a sample for understanding the impact of the piped water supply on the community through the MVS.

Table 1: Details of MVSs under study

A basic profile of the MVS under study					
Name of the scheme	Rajauli Multi-village Piped Water Supply Scheme	Mouzampur Multi-Village Scheme	Cheria Multi-Village Scheme	Khaira Multi-Village Scheme	Kahalgaon-Pripainti Multi-Village Scheme
District	Nawada	Bhojpur	Begusarai	Munger	Bhagalpur
GP where WTP is located	Hardiya	Nargada	Shripur	Ramankabad West	Shyampur
Water-quality issue	Fluoride	Arsenic	Iron	Fluoride	Arsenic
Date of inauguration	December 18, 2019	June 10, 2010	August 25, 2020	May 30, 2017	August 28, 2020
Capacity of the WTP (in MLD)	9.5		6.73		30.5
No. of villages covered	92	23	11	24	141
No. of GP covered	10	7	5	2	36
Total no. of HH targetted	8750	16,073	9480	10000	47302
Total no. of tap connection provided	9191	10738	8225	9300	46906
Source of inlet water	Phulwariya dam	Ganaga river	Budhi Gandak	Kharagpur lake	Ganga river
No. of MESR	1	1	1	1	2
No. of ESR	6	11	5	3	16
Total length of the pipeline (in kms)	170	215	72.5	39.7	932
Agency looking after the O&M	JWIL Infra Limited	Avian Infrastructure	GDCL, New Delhi	Avian Infrastructure	JMC Projects Pvt. Ltd.

STAKEHOLDERS INVOLVED

The prime stakeholders of the MVS in the five districts ranged from the district level functionaries including Executive Engineer, Assistant Engineer, Junior Engineer who were involved in the overall monitoring and management of the scheme, implementing agencies responsible for the maintenance and management of the operation of source (pumping from an intake well), source to main storage tanks, and thereafter to village storage tanks, and the community members who were the main beneficiaries of the scheme.

SCHEME DETAILS

In all the five MVS under study, surface water such as rivers and dams are used as a source of the raw water collection point. The water is properly treated through a water treatment plant and clean water is supplied to the villages through piped water connection at the household level. A brief overview of the schemes may be seen in the table ahead.

RAJAULI MVS, NAWADA DISTRICT

Among the picturesque surroundings of majestic hills looking down upon the azure crystal clear waters is the sprawling Phulwariya dam spread over 179.2 square kilometers, providing water to the Rajauli MVS. This dam being a source for inlet water is rainfed and can be characterized as one with water of reasonably good quality in its raw form, with minimal chemical impurities, and only minor deviations from ideal parameters. This surface drinking water project is located in the Hardia Panchayat of the Rajauli Block of Nawada district in the state of Bihar. The groundwater in many gram panchayats under Rajauli Block and its environs were found to be affected by fluoride contamination, and consequently, the majority of the population living in these villages suffered from dental and skeletal fluorosis. This MVS covers ten Gram Panchayats namely East Rajauli, West Rajauli, Chitrakoli, Hardia, Sirodabar, Takuatand, Jogia Maran, Bahadurpur, Dhamani, and East Amawan. Its operation and maintenance (O&M) have been handed over to JWIL Infra Limited to provide safe and potable drinking water to the 10 fluoride-affected Gram Panchayats in Rajauli block. The ambitious Rajauli MVS was conceptualized to cater to the needs of 8750 households (HHs) spread across the 90 villages and 89 wards of the ten Gram Panchayats. To date, FHTC has been provided to 9191 households of 128 wards of 92 villages, thereby exceeding the set target.

KHAIRA MVS, MUNGER DISTRICT

Khaira Multi village scheme is located in the Ramankabad West Panchayat of Haveli Kharagpur block in Munger district. The present coverage of Khaira Multi Village scheme is in 13 wards of Ramankabad Panchayat and 18 wards of Nagar Parishad. A total of 9300 tap connections have been provided so far and work is in progress for providing the remaining 2845 connections. The source for the inlet water in this scheme is Kharagpur lake. One of the key challenges faced in the construction of the water treatment plant was the disturbance created by left-wing extremism but community involvement and support became instrumental in overcoming this challenge and at present, it is operating smoothly. The scheme was earlier a part of Neer Nirmal Pariyojna where stand post was the mode of water supply, which was later substituted by tap water connection at the household level under the Har Ghar Nal ka Jal scheme.

MAUZAMPUR MVS, BHOJPUR DISTRICT

Mauzampur is the first MVS in Bihar with its main source being the Ganga River. This scheme, inaugurated in October 2010 in the Nagrada Panchayat of Barhara block of Bhojpur supplies water to 10738 households spread across 23 villages of 7 Gram Panchayats.

Until some years ago, people were mainly dependent on hand pumps and wells for clean drinking water. But the confirmation by the health authorities about the region being highly arsenic affected causing skin manifestations and cancer brought the issue of groundwater contamination into prominence. Moreover, this area falls under the flood zone which further compounds the issue of contamination of water. Water is being supplied through a 215 KM length of pipeline spread across the project area. The capacity of the reservoir is under the process of expansion and with the extended capacity of the water, it is expected that water would be available to more households, the current target being 16073.

CHERIA MVS, BEGUSARAI DISTRICT

The multi village water scheme is located at Shripur village of Shripur Panchayat in Cheria. At present, this scheme covers 8225 out of 9480 targeted households spread over 5 Panchayats,11 villages, and 70 wards. Inaugurated in August 2020, the surface water of Budhi Gandak is used for treatment and distribution in the villages of the project area.

The groundwater of these areas is highly iron contaminated causing health hazards like hair fall, constipation, gastritis, nail, and dental problems, etc. Besides, it is not suitable for domestic use such as cooking. Piped water connection is made available to the villages through this scheme using a 10.5 km rising main network and 62 km distribution network.

KAHALGAON MVS, BHAGALPUR DISTRICT

The uniqueness of Kahalgaon - Pirpainti multi-village scheme lies in its bulk water distribution network, meeting the needs of 46,906 households of 36 Gram Panchayats and 141 villages, as against an enormous target of 47,302 households. The floating jetty with its floating gangway situated in the scenic location of the vastness of the holy Ganga River, makes this MVS stand above the rest. The groundwater of these villages is contaminated with arsenic above the permissible limit. There is a provision of raw water intake through a floating jetty with a floating gangway from Ganga River to the resettling tank of the water treatment plant.

TRANSFORMING LIVES THROUGH MULTI VILLAGE SCHEMES

The ambitious project of providing piped water connection to every household through the MVS has yielded profound socio-economic and health impact, transforming the lives of the community wherever it has been installed. The launch of this MVS has brought contentment and ease of living in the areas covered by the scheme leaving a lasting effect on the community to enable them to lead a fulfilling, healthy and productive life. These impacts recorded below are based on the information gathered through focus group discussions, individual interviews with different stakeholders, interpersonal communication with the community, and physical observation in the five MVSs under study.

Health

Overall health impact of this surface water scheme has been far from satisfactory as the good quality , contamination-free water has resulted in mitigating a host of health problems the community was exposed to, earlier. Before the establishment of the MVS, the community in these five study areas was affected by water-borne diseases due to the consumption of chemically contaminated water. Infested with worms, the water had several quality issues like bad odour and colour and unpleasant taste. Supply of surface water from ponds, rivers, lakes etc. through pipe network after going through a variety of technological treatmnet processes has yielded commendable results in countering the contamination issue of groundwater for drinking purposes.

The villagers of Purani Hardia of Rajauli block shared that the conventional sources of water available were wells and borewells which were contaminated with excess fluoride causing health dangers. Fluoride is an acute toxin and

moderate-level chronic exposure (above 1.5 mg/litre of water - the WHO guideline value for fluoride in the water) leads to dental effects characterized by staining and pitting of the teeth, but long-term ingestion of large amounts can lead to potentially severe skeletal problems manifesting itself in stiffness and pain in the joints and change in the bone structure, with resulting impairment of muscles and pain.

Dental and skeletal fluorosis was reported to be rampant in Rajauli, where a few toothless villagers with twisted limbs are still not an uncommon sight. Almost all villagers in Khaira and Mauzampur unanimously complained of the problem of distension in the stomach, indigestion and acute gastritis which they say has waned off considerably with the coming of clean and pure water from the piped water connection. Echoing the common concern of the community, Phulmanti Devi of village Purani Hardia of Rajauli block, said, “we suffered from abdominal and knee pain due to the consumption of poor quality of water but thanks to the Nal Ka Paani (tap water) for relieving us from these health burdens”.

Anil Rajvanshi of Rajauli informed, “most of the children born 15 years back were victims of impaired legs and hands, with noticeable yellow stains on their teeth but with the installation of a safe drinking water supply system in the village, and the use of tap water for drinking and cooking purposes, the result was miraculous”. Now that she has started using safe water, Phulmanti Devi is happy and hopeful that the teeth of her young children will not degrade further.

Similar health hazards could be observed in Banbarsa village of Ramankabad West Panchayat of Munger district where Khaira MVS is operational. An interesting case was reported by the field level functionaries of Khaira about the village facing a social boycott in the past with girls not being given in marriage to boys of this village due to fluorosis menace. But evidence has revealed that the intervention has drastically brought down the incidences of fluorosis and the community. So strong is the impact of this scheme that the community, now assured of the benefits of safe drinking water, is even willing to pay a nominal monthly fee of Rs.50/ to Rs. 100/- for the maintenance of piped water connection.

“The sight of water flowing from the tap was a feast for us”, says Indrajeet Singh, a resident of the beneficiary village, Mauzampur in Bhojpur district This district was reported to be severely exposed to drinking arsenic-contaminated hand tube-wells water above the permissible limit of 50 µg/L almost two decades ago with grave health effects ranging from various types of skin manifestations and other arsenic toxicity to gangrene and cancer. The advent of piped water and the accessibility to safe water has resolved these health issues since no such infected person could be observed during the course of the study.

Socio-economic impact

Water being a basic necessity, a large part of the time was squandered in water management activities including collection and storage of water. The establishment of the new scheme in these five study areas has benefitted the community by bringing about improvement in their socio-economic status. They now have more time to pursue income generation and agricultural activities and taking care of their livestock. Besides, the community expressed satisfaction over the economic benefit accruing in terms of savings due to minimal expenditure on medical treatment due to contamination-related diseases. “There has been a considerable reduction in our visit to the local doctors due to the installation of piped water connection in our household. We are now getting safe and potable water which is a boon for us”, exclaimed Badri Rajvanshi of Rajauli block in Nawada district.

The piped water connection has saved them from the extra expenditure they earlier made on purchasing water to meet their needs, amounting to Rs. 700 to 800 in a month, which posed ‘a heavy economic burden’ only a few affluent ones could afford. Shared Fudo Mahato and Saket, the residents of Shripur village of Shripur Panchayat in Begusarai district, “the poor quality of water compelled us to spend Rs 50/- to Rs 60/- per day to buy filtered water from outside. So, we are ready to contribute monthly water tariff as operational cost, if demanded at any time in the future”.

At some places, an expansion of livelihood opportunities and consequent check on migration with the involvement of the community in the construction activities has been reported by the community. Shared Prabhash Kumar Ray, a resident of Shyampur Panchayat of Kahalgon- Pirpainti village of Bhagalpur district. “We are not only getting tap water at home but also employment opportunities because of the establishment of the MVS. Migration to urban areas in search of livelihood has come to a halt since with the onset of the construction activities, approximately, 40-50 people are now engaged on the site itself”. Balmiki Kumar Rai of the same village appeared to be contented with the alternative employment of laying out pipes in which he was engaged during the construction stage of the MVS.

Quality and quantity of Piped water supply

Talking about the quality of groundwater consumed earlier, the residents of Khalgaon-Pirpainti in the arsenic-affected Bhagalpur district informed that it was muddy and dirty with worms floating all around making it unfit for consumption and cooking. Cooking was a cumbersome ordeal with the rice and pulses often requiring greater time for cooking and the colour of cooked food turning red. Recalling the ill effects of the iron contaminated water in Shripur Panchayat of Cheria village in Begusarai district Reena Devi, a resident of Gachhi Tola says, “hand pumps were the source of drinking water available to us but the water supplied was not suitable for domestic use and even for taking bath as it caused hair loss and entanglement”. The high concentration of iron in the water led to yellowing of utensils, less foaming of soaps, and the colour of tea turning black on boiling.

MVS water is suitable for cooking and drinking purposes, being pollutant-free, fresh, and hygienic. “The tap water available now is clean and tasty and relatively less time is required to cook rice and pulses. The quantity of water is adequate to enable us to undertake our daily chores with relative ease and now even our animals can use the surplus water at home for drinking purposes”, says a happy Sulekha Devi, a resident of the beneficiary village. The contentment and joy is writ large on the faces of the people, men and women alike, who join to express their satisfaction at the assured and regular water supply.

Shared Badri Rajvanshi, “Life has become relatively more comfortable as we are free from anxiety related to disrupted water supply in the past and we can now store almost three to four buckets of water for usage later in the day”. The MVS plants in almost all our study areas, provide water at the household level twice a day, for 2 to 3 hours each, during morning and evening. On average, households receive piped water for 4 to 6 hours a day. However, the community in Kahalgaon-Pirpainti shared that at times, water supply is disrupted due to power failure and pumping issues when the villagers have to access water from alternative local sources like tube wells in the village. Minor repair issues related to the water supply at the household level like leakages and breakdown, they said, are resolved by the pump operators or by the local plumbers which takes one to three hours to be completed while major repair work is done by the Junior Engineer (JE) with the support of the dedicated agency/contractor, which is usually completed in a day or two.

Sanitation

With the piped water connection available at the household level, safe sanitation and hygiene practices have improved. Says Geeta Devi of Rajauli block “Since I have got an answer to my biggest worry, I can now concentrate more on other things like personal hygiene and sanitation. All household members take regular baths, drink safe water, and open defecation in the village has reduced with the increase in toilet usage due to increased access to safe drinking water. Urmila Devi, a beneficiary of the same block admits that before the launch of this scheme, people used to take baths at an interval of 5-6 days but now with the availability of clean tap water in an assured quantity, they can now indulge in bathing every day, which for them is a rare experience.

Gender Impact of MVS

Traditionally, the water sector displays differential gender roles with women primarily responsible for the collection, storage, and purification of water for drinking, cooking, and other domestic chores. As shared by the women present in the discussion, the male members of the community offered no support in this water-bearing task which imposed a gendered burden on the women and young girls alone. Says a beaming Sunita Devi," We are now independent of the heavy burden of pulling water from the wells and carrying as much as 50 kilos of water every day in heavy-bottomed vessels". But even today all chores related to the storage and purification of water are the responsibility of women alone.

The positive impact of the scheme is visible in confident and relaxed women speaking at length on the benefits of this scheme. The availability of clean water close to home has reduced women's workloads, and the time saved in fetching water may be spent on other social responsibilities and engagement in the family's livelihood activities. Her face glowing with a new found sense of independence, an elated Indira Gupta who has been residing in village Purani Hardia of Rajauli for the last twenty-five years, exclaims "access to piped water supply has relieved the hassle of going to far-off places to fetch drinking water. Traversing long distances, we squandered 2-3 hours of our crucial time which we now devote to taking care of our children".

The male members of the community voiced genuine concern about the deteriorating health condition of the females in the past as a result of fluoride contaminated water but now with the coming of piped water, women are relieved from the agonizing pain in their abdomen and stiffness of joints and their efficiency for doing multiple household chores has become double-fold. Says Anil Rajvanshi, "Earlier water scarcity was met by procuring ten to fifteen buckets of water from the wells and nearby rivers which was very time consuming, taking a toll on their health. but now they get ample time to take rest to replenish their energy".

SUSTAINABILITY OF MVS

It is imperative to understand the significance of MVS based on surface water supply from the long-term sustainability perspective in terms of economic viability and social acceptability. The MVS is meeting the needs of multiple panchayats for safe drinking water through a centralized water treatment plant system. Here economies of scale can be a positive factor in terms of production and delivery of drinking water to cater to the needs of larger sections of the community[7].

[7] *https://documents1.worldbank.org/curated/en/818101468034786562/pdf/447920PP0P09411413B01PUBLIC10PAPER3.pdf*

The cost of supply is reduced and options are broadened since several villages are being served by one scheme. The state is rich in surface water and the advantage of tapping surface water sources lies in their being less affected by seasonal variations thus ensuring regular water supply.

Figure 5: Glimpses from the field

The groundwater contamination is high in Bihar resulting in water-borne health hazards and its overexploitation is an alarming trend having an adverse impact on the groundwater quality and quantity as well. In such a situation, the MVS could be a feasible solution for a long-term clean water supply unit. Source Sustainability of MVS based on surface water can be assured since it can be replenished through rainfall, offering a safe and easy alternative solution to the areas affected by groundwater depletion. The willingness of the community to contribute in the form of water tariffs in lieu of good quality and assured supply of water may go a long way in strengthening the sustainability of MVSs.

WAY FORWARD

- The operation and maintenance of the water treatment plant (WTP) in all five locations are being handled by a third-party agency for a period of five years. A perspective plan, for the operation and maintenance of the scheme, subject to review and appraisal after five consequent years may be developed with a vision to ensure the sustainability of the scheme.

- The MVS being a costly and complex affair, and communities lacking sufficient social and human capital to develop the more sophisticated institutional systems to manage the services, a bottom-up approach to the water management system in the villages is a difficult and impractical proposition. The role of community participation in the implementation of the schemes may be strengthened by engaging them in basic operational tasks, maintenance, and monitoring process from the distribution line to the household. Such a community-managed distribution would help

to instill a sense of ownership in the community and increase people's identification with the scheme thereby mobilizing them to maintain them in good order.

- Field experience of the projects demonstrated a lack of involvement of women in water supply schemes and a need to integrate a gender perspective in the design and implementation of projects. Community participation in the water supply schemes with an emphasis on equal participation between men and women in the decision-making process, implementation, operation and maintenance, and monitoring may be considered. Women's traditional roles as primary users and collectors of water may be recognized and their existing knowledge on water issues can be used in the identification of the source, selection of sites, pump maintenance, water quality testing, and in the maintenance of hygiene and cleanliness from the service reservoir to the handposts.

- Information, Education, Communication (IEC) activities are one of the important aspects which need to be strengthened in villages to raise awareness levels of the community regarding proper handling, storage, and misuse of water. Lack of awareness related to groundwater contamination and its hazardous effects on health was observed which may be addressed by a strategic advocacy and communication campaign.

- As reported by the villagers in some regions, some of the piped water schemes do not function for two to three days in a month either due to system breakdowns or expansion of existing schemes. Irregularities in the supply of water caused by the interrupted power supply can be met by the strengthening of the existing provisions for power backup in the MVS to ensure the continuous availability of water. An effective message delivery mechanism may be developed to give prior information to the community in cases of pre-planned power cuts to enable them to make alternative arrangements for water storage and use, avoiding hassles and stress in domestic work.

- In areas where multi village schemes are operational, the highest priority should be given to water quality surveillance. Since water has to be transported from long distances, in addition to chemical contamination, there is a high risk of bacteriological contamination. There should be a focus on measuring, reporting, and tackling bacteriological contamination in sources, storage, transmission, delivery points, and within households during storage and use. As a cost-effective solution, bacteriological testing kits may be provided to the community members, preferably women, who can be trained for testing water quality through the use of these kits, for achieving household-level drinking water security.

- The different types of piped water supply schemes have their benefits and limitations. Where surface water availability is assured and in abundance, surface water-based MVS is a feasible solution to supply potable water in the quality affected areas. The groundwater schemes have become unreliable in many places and even redundant in some places due to unsustainable sources. Besides, water quality has increasingly become a concern as the groundwater tables have gone down over the years. To address these twin problems, surface water-dependent multi village schemes (MVS) may be promoted.

- The 73rd Amendment of the Constitution envisaged the devolution of powers to the Gram Panchayats (GPs) in the management of the local water supply systems. The visit to the assigned areas displayed a lack of involvement of the GPs. For efficient implementation and sustainability of the scheme, the capacity of GPs may be strengthened in planning, management, operation, and maintenance of in- village water supply systems including the selection of drinking water sources, keeping the sources hygienic and clean, and ensuring recharge of the aquifer.

- The surplus treated water from the multi-village scheme (MVS) may be sold to commercial establishments like hotels, offices, small-scale industries, etc to generate revenue for its long-term sustainability.

The Story: Then and Now

The twenty-five-year-old boy, Santosh Kumar Manjhi, has no story to tell. Plagued by fluorosis and orphaned at the age of ten, with twisted bones and crippled legs, teeth yellow and stained, his entire life stands staring blankly at him. Unable to fend for himself and left at the mercy of his only brother and the villagers to take care of him, he is a silent spectator, gazing aimlessly at the sky. Relating his sad saga, a villager, Anil Rajvanshi said, "Santosh's father was also afflicted with this deformity which was inherited by his son. Many children born a decade ago suffered from similar visible symptoms about which we were in total darkness. But now, with the coming of safe water through pipelines, this disease has receded and we are heaving a sigh of relief".

Figure 6: Santosh Manjhi, a resident of Hardiya Panchayat, Rajauli, Nawada

Santosh's story is just an isolated reflection of the plight of the residents of Purani Hardia tola of Hardia Panchayat, Rajauli block in Nawada district of Bihar. Manjhi's pitiable state is a result of Fluorosis, a disease caused by the long-term ingestion of large amounts of fluoride consumed through contaminated water. However, varied cases of hazardous health implications, arising out of groundwater contamination have been reported across different regions of Bihar. Surveys and researches have shown that the groundwater contamination issues in Bihar are rising over the years with the state health authorities declaring drinking water contaminated by arsenic, nitrate, fluoride, and iron as unfit for human consumption.

S. No.	Characteristic	Unit	Requirement (Acceptable Limit)	Permissible Limit in the absence of alternate source
1.	pH value	–	6.5 - 8.5	No relaxation
2.	Total dissolved solids	Milligram/ litre	500	2,000
3.	Turbidity	NTU	1	5
4.	Chloride	Milligram/ litre	250	1,000
5.	Total alkalinity	Milligram/ litre	200	600
6.	Total hardness	Milligram/ litre	200	600
7.	Sulphate	Milligram/ litre	200	400
8.	Iron	Milligram/ litre	1.0	No relaxation
9.	Total arsenic	Milligram/ litre	0.01	No relaxation
10.	Fluoride	Milligram/ litre	1.0	1.5
11.	Nitrate	Milligram/ litre	45	No relaxation
12.	Total coliform bacteria	Shall not be detectable in any 100 ml sample		
13.	E.coli or thermotolerant coliform bacteria	Shall not be detectable in any 100 ml sample		

Permissible limit for the basic water quality parameters

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