Annual Progress Report

"FLUOROSIS MITIGATION IN THE SELECTED VILLAGES OF SONBHADRA DISTRICT, UTTAR PRADESH"

Duration: September 2020 to November 2021

Submitted to
People for Progress in India (PPI)

By

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Brief description of the Problem:

Banwasi Seva Ashram (BSA), a voluntary organization located at Govindpur, has identified many cases of Fluorosis in dozens of villages of Chopan, Dudhi and Myorpur blocks (https://www.indiawaterportal.org/articles/fluoride-testing-and-fluorosis-mitigation-sonabhadra-district-uttar-pradesh-study-peoples). These blocks are dominated with tribal communities.

Recently a study was carried out by Banwasi Seva Ashram (BSA) and People Science Institute Dehradun (PSI) in 21 gram panchayats for drinking water quality tests and estimated fluoride content which showed fluoride concentrations beyond the permissible limit which is 1.1 – 5.4 mg/L in surface water and 0.5 – 5.9 mg/L in groundwater (>1.5 mg/L as per the standard of BIS (IS-10500-2012) and WHO-2006). This joint study revealed a serious occurrence of Fluorosis (for both Dental and skeletal Fluorosis) in these gram panchayats.

Selection of villages for the study: In villages near to BSA that are Kusmaha and Govindpur, we found seriousness of dental and skeletal Fluorosis.

1. Village Kusmaha:.

The village Kushmaha falls in Sonbhadra district situated in Uttar Pradesh state, with a population 1439. The male and female populations are 747 and 692 respectively. The size of the area is about 6.1 square kilometer. Fluorosis affected population is 848 as per study in year 2004. In one school, 23 students out of 37 students were found affected with dental Fluorosis and 8 people are seriously suffered with skeletal Fluorosis. 72% of total available water sources have found more than 2 mg/L of fluoride and one source of water showed 10mg/L fluoride concentration (Study report, PSI 2004).

2. Village Govindpur:

The village Govindpur falls in Sonbhadra district situated in Uttar Pradesh state, with a population 562. The male and female populations are 304 and 258 respectively. The size of the area is about 6.14 square kilometer. Fluorosis affected population is 355 as per study in year 2004. Dental Fluorosis was much frequent. 81 % of total available water sources have found more than 2 mg/L fluoride concentration.

Goal of the Project: Ensuring Fluorosis mitigation in selected villages and establishing a model for Fluorosis mitigation.

Objectives:

- To identify safe sources of all the drinking water sources in selected 2 villages Kushmaha and Govindpur.
- Assess the current prevalence of fluorosis in the above selected villages.
- Prepare plans and their implementation to reduce the prevalence of fluorosis in the selected villages through providing safe drinking water and nutritional interventions.
- To investigate the relationships between the incidence of fluorosis and the concentration of fluoride in the drinking water in these villages.

- Involve village health nutrition & sanitation committee (VHNSCs) of local body in all the process and promote local governance ownership.

Project Plan: The proposal has divided in phases for the implementation of our study strategy and the mitigation approach against fluoride affected target villages.

S. No	1st phase (Sept 2020- August 2021)	2nd Phase (Sept 2021- August 2022)
1	Fluorosis health survey of two villages Kusmaha and Govindpur villages	• **Regular monitoring and impact analysis** • Water defluridation kit monitoring and Fluoride testing • Urinary fluoride Testing • Blood and Serum calcium test • X-ray • Nutrition Interventions • Monthly Record keeping
2	Water quality monitoring of all the drinking water sources Sample collection, results and analysis	**Analysis of Impact** • Detailed Comparison study report • Analysis of health improvement wrt Fluorosis
3	Urinary Fluoride test in two villages.	**Nutritional Study of RO water and in selected natural drinking water sources for quality parameters** • Improvement in drinking water security plan and need based water quality test • Protection and conservation of secured water sources in Village • Development of actionable water security plan for each ones in Village
4	**Community meeting** Meeting with VHNSC and focus on Fluorosis Mitigation as an agenda for Gram sabha	**Community meeting** Meeting with VHNSCs and focus on Fluorosis Mitigation plan as an agenda for Gram sabha
5	Selection of most affected 100 households	Large scale Sandesh Yatra in nearby villages and a conference to disseminate the outcome. Meeting with Govt implementing agencies and district administration
6	Selection and medical test of 100 affected persons from the 100 Households (Blood, Serum Calcium and Uric acid) X-ray of severe cases among selected persons	
7	**Drinking water security plan for selected HHs:** Alternative strategies, defuridation kit,	
8	**Nutritional interventions in selected 100 HHs:**Medical supplements, traditional home based therapy, promotion of Poshan Vatika	

Details of Fluorosis Mitigation Project
Duration: Sept 2020- November 2021
in Kushmaha and Govindpur Villages

1. Health Survey:

284 HHs in Kushmaha and 104 HHs in Govindpur were surveyed. Total 1793 persons are covered in the survey as shown in Table 1 and 2

Table 1 Kushmaha:

SN	Description	Values
1.	Number of HHs surveyed	284
2	Number of persons surveyed	1323
3	Number of HHs affected with Serious dental Fluorosis	44
4	Number of persons affected with Serious dental Fluorosis	176
5	Number of HHs affected with Serious Skeletal Fluorsosis	11
6	Number of persons affected with Serious Skeletal Fluorosis	32

Table 2 Govindpur:

SN	Description	Values
1.	Number of HHs surveyed	104
2	Number of persons surveyed	416
3	Number of HHs affected with Serious dental Fluorosis	11
4	Number of persons affected with Serious dental Fluorosis	26
5	Number of HHs affected with Serious Skeletal Fluorosis	5
6	Number of persons affected with Serious Skeletal Fluorosis	9

During survey we used set of questions and trained our health friends to identify the severity of fluorosis then we start sorting of surveyed people based on the answers of questionnaire and on the various symptomatic observations. We categorised them in different category of fluorosis:

1. Dental Fluorosis: This is identified by staining and pitting of the teeth. In more severe cases all the enamel may be damaged.

(a) **Serious:** completely affected enamel surfaces, pitting teeth, all the teeth either discrete or run together

(b) **Medium:** white opaque areas affect more than 50% of the enamel surface

(c) **Mild:** white opaque areas on the surface are more extensive and affect less than 50% of the surface

(d) **Doubtful:** Enamel shows slight changes from white flecks to white spots

(e) **None:** No symptoms

2. Skeletal Fluorosis: Fluorosis is reported as a crippling disease resulted from the deposition of fluorides in the hard and soft tissues of body. The early symptoms include stiffness and joint pain. In severe cases, changes may occur in bone structure with the calcification in ligaments which together resulted in impairment in flexibility of muscles affecting its functioning and pain. Also constriction in vertebral canal and foramen exerts pressure on nerves and blood vessels causing paralysis and pain.

Physical tests were conducted during the survey in both the villages. We performed following three test to evaluate the severity of skeletal fluorosis:

1. Touching the toes without bending the knees
2. Touching the chest with the chin
3. Stretching of the arms and folding them to touch the back of the head

On the basis of the above symptomatic observation we categorised the surveyed people into the followings:

(a) **Serious:** completely unable to perform test 1, 2& 3
(b) **Medium:** performed up to the 50 %
(c) **Mild:** performed less than 50 %
(d) **Doubtful:** sometimes pain in joints
(e) **None:** no pain in joints, no problem in movement

Table 3: Different level of Fluorosis observed during survey in both the villages
(A)

Dental Fluorosis					Skeletal fluorosis				
Serious	Medium	Mild	Doubtful	None	Serious	Medium	Mild	Doubtful	None
202	327	853	400	11	41	386	983	352	31
11.26%	18.23%	47.57%	22.30%	0.61%	2.28%	21.52%	54.82%	19.63%	1.72%

(B)

S. No.	Skeletal cases	Kushmaha (in 1323 surveyed people)		Govindpur (in 416 surveyed people)	
		Male	Female	Male	Female
1	Number of serious cases	11	21	3	6
2	Number of medium cases	132	168	41	45

Table 3A shows the dental and skeletal fluorosis under various category of severity in both the villages. Table 3B gives detail of serious and medium skeletal cases shown in both villages. We observed the more skeletal cases in females may be due to the dietary differences in a family. Usually female members are not caring herself about the nutritious food.

2. Fluoride concentration in drinking water sources:
Total 86 water sources were tested in Kushmaha and 33 water sources in Govindpur as mapped in Fig 1 and 2.

Fluoride concentration varied between 0.6-7.26 mg/Lin Kushmaha while 0.8-6.76 mg/L in Govindpur (showing in Fig-3 and 4- yellow to darker red region). Also these data representing house wise dependency on water sources (Handpump, Well, RO plant etc).

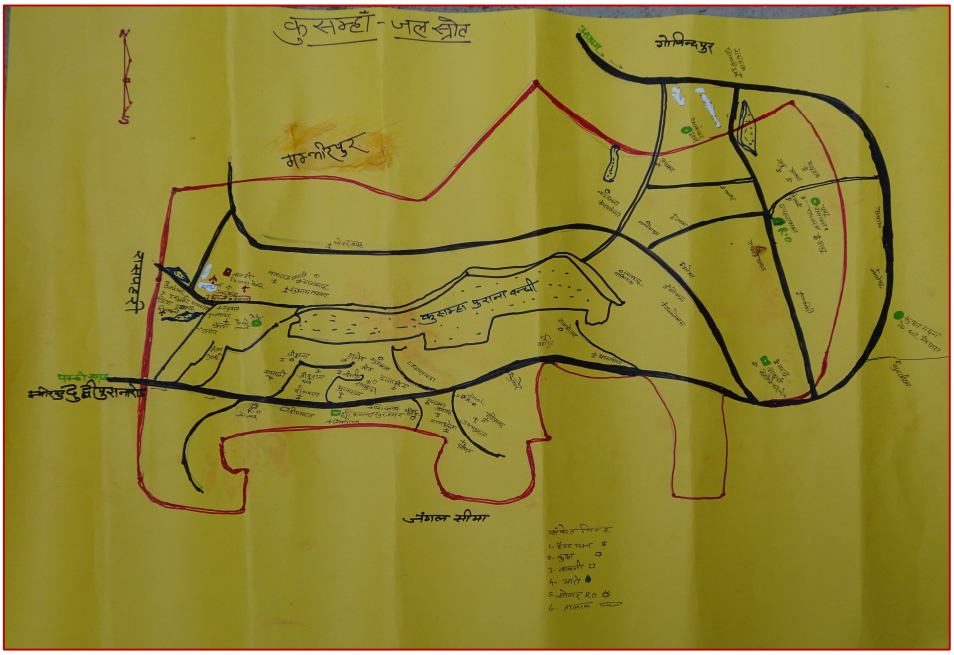


Fig 1 Mapping of available water sources and drinking water dependency in Kushmaha village

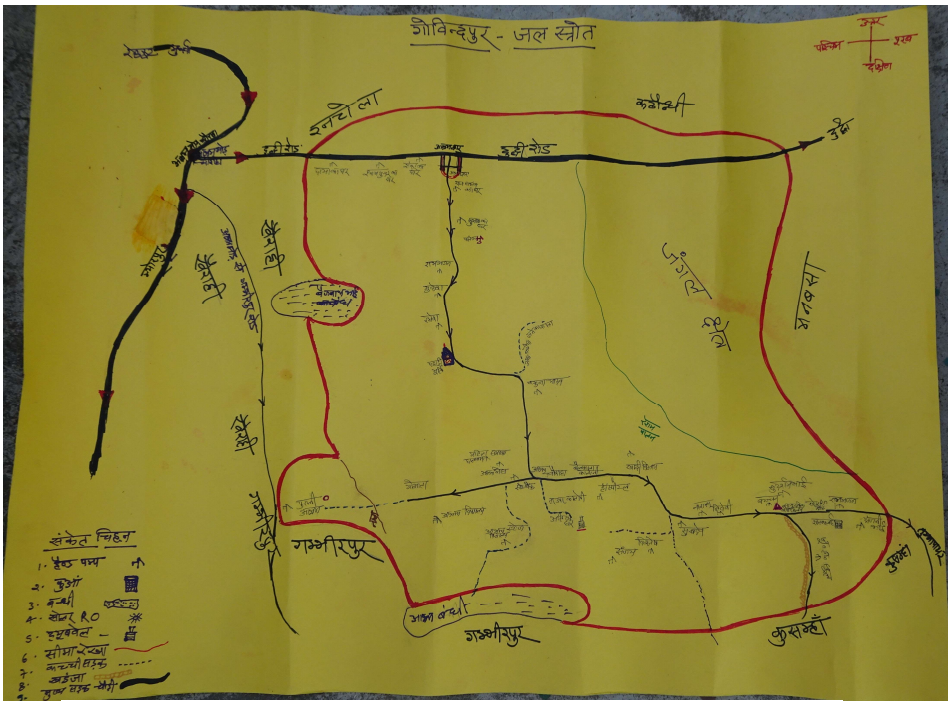


Fig 2 Mapping of available water sources and drinking water dependency in Govindpur Village

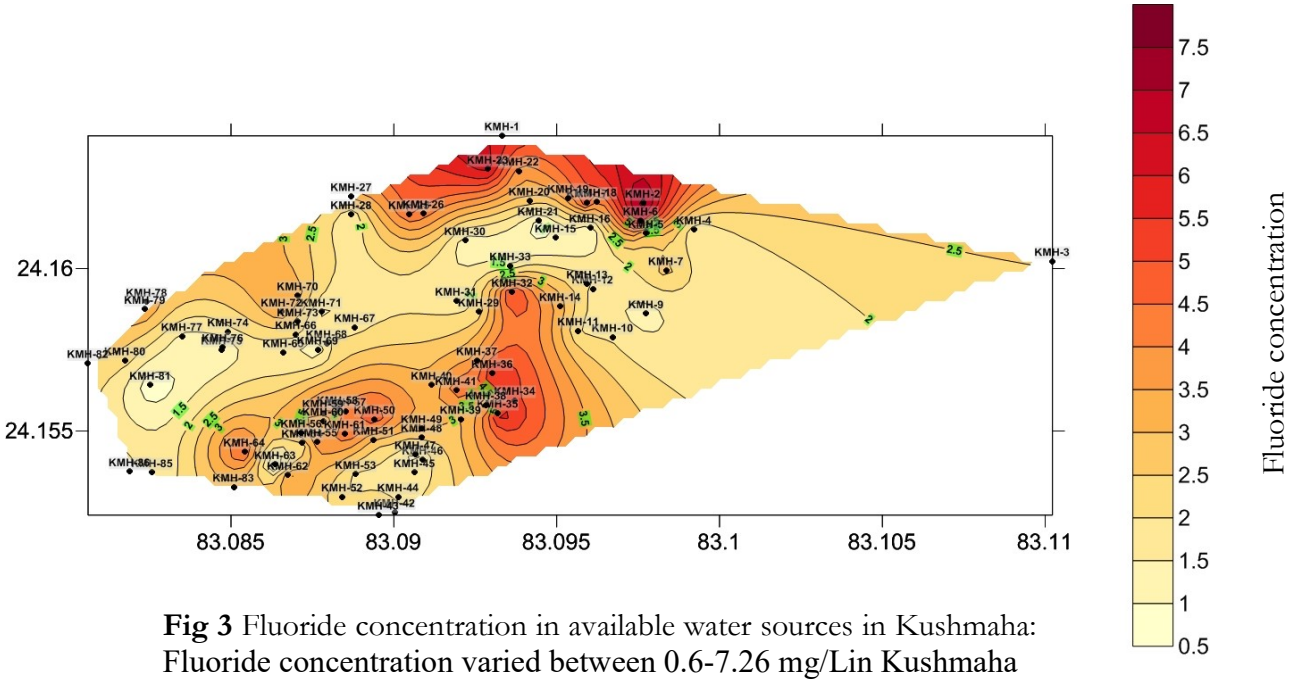


Fig 3 Fluoride concentration in available water sources in Kushmaha: Fluoride concentration varied between 0.6-7.26 mg/Lin Kushmaha

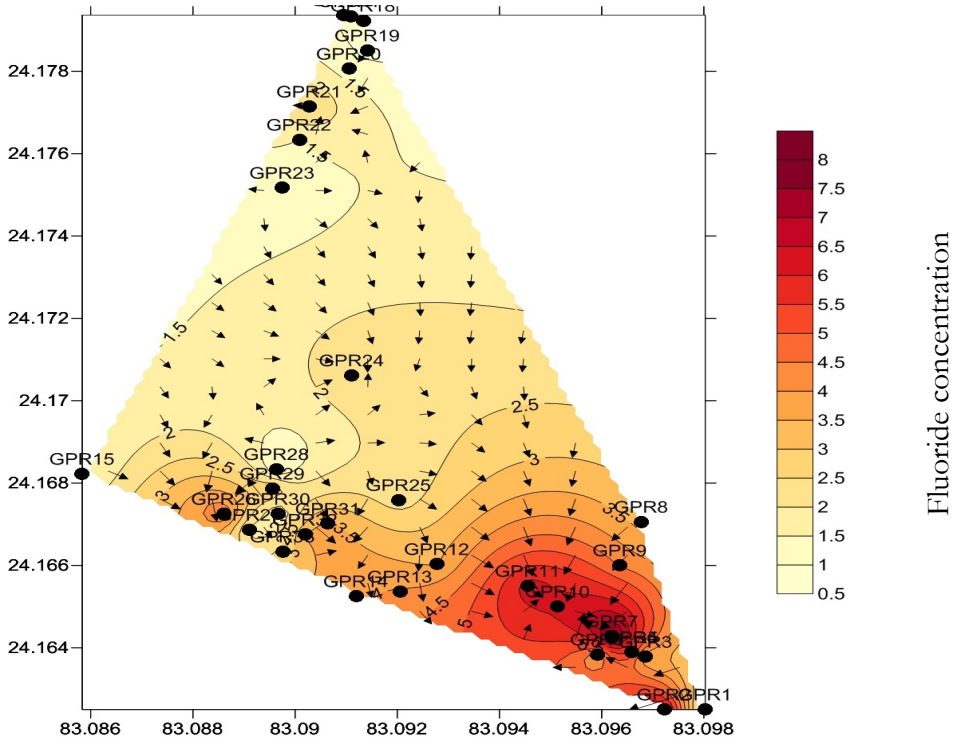


Fig 4 Fluoride concentration available water sources in Govindpur. It ranges from 0.8 to 6.76 mg/L

Urinary Fluoride testing:
Urine samples were collected from 345 persons in Kushmaha and 229 persons in Govindpur and tested for fluoride concentration. Important observations are summarised below:

Table 4: Urinary Fluoride data

Village	Urinary Fluoride (>10 ppm)	Urinary Fluoride (5-10 ppm)	Urinary Fluoride (1.5-5 ppm)	Urinary Fluoride (<1.5 ppms
Kushmaha	28 persons	141 persons	166 persons	10 persons
% age	8.12	40.86	48.11	2.89
Govindpur	2 persons	50 persons	151 persons	26 persons
% age	0.87	21.83	65.93	11.35

Community meeting and Awareness:
In both the villages community interactions were done and they were informed about fluoride concentration in their drinking water sources. A team of volunteer was formed to help and spread the fluoride risk in their village. Fig 5 and 6 were posted at Panchayat house for community awareness.

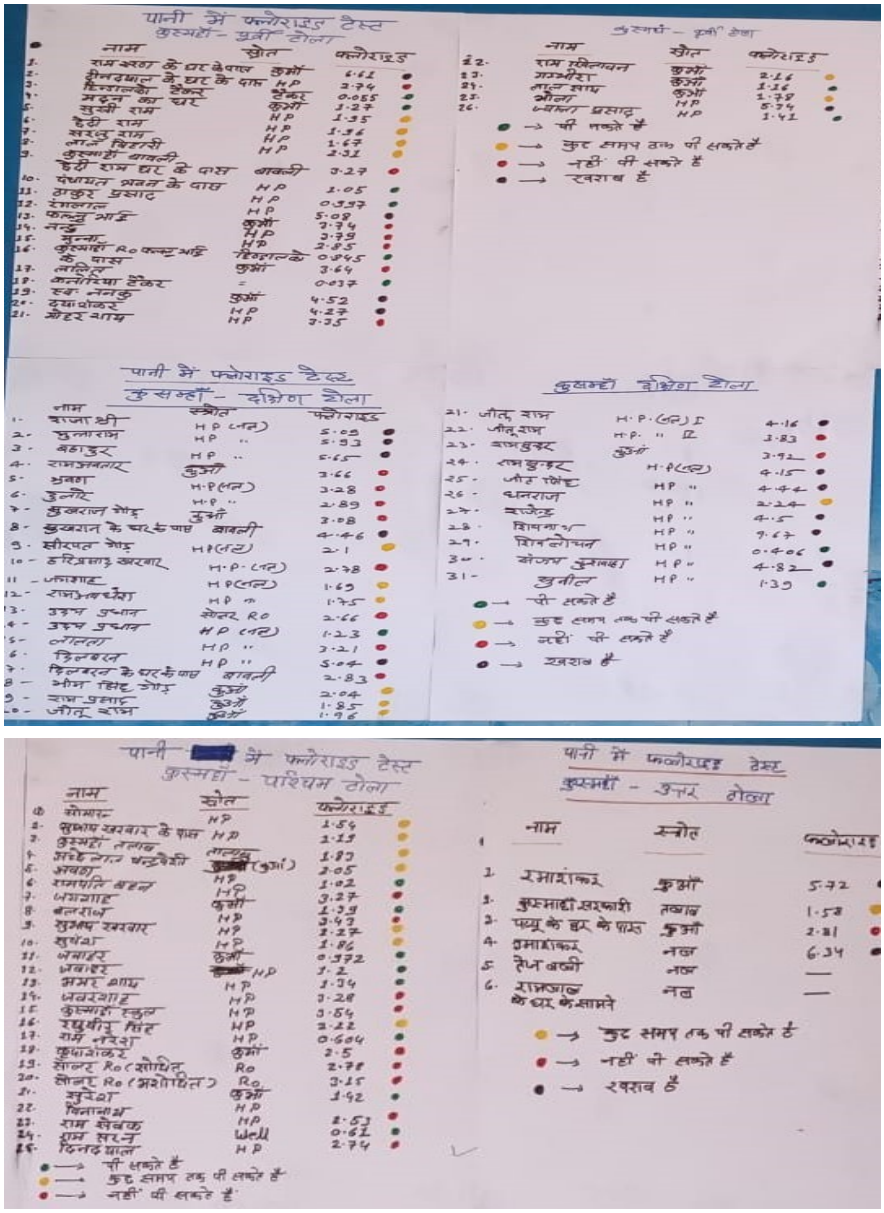


Fig 5 Kushmaha village

Drinking water sources colour marked with green, yellow, red and black showing the level of fluoride.

Green- safe

Yellow- under danger

Red- can not be consume but can be use for other uses like agriculture

Black- can not be use either way

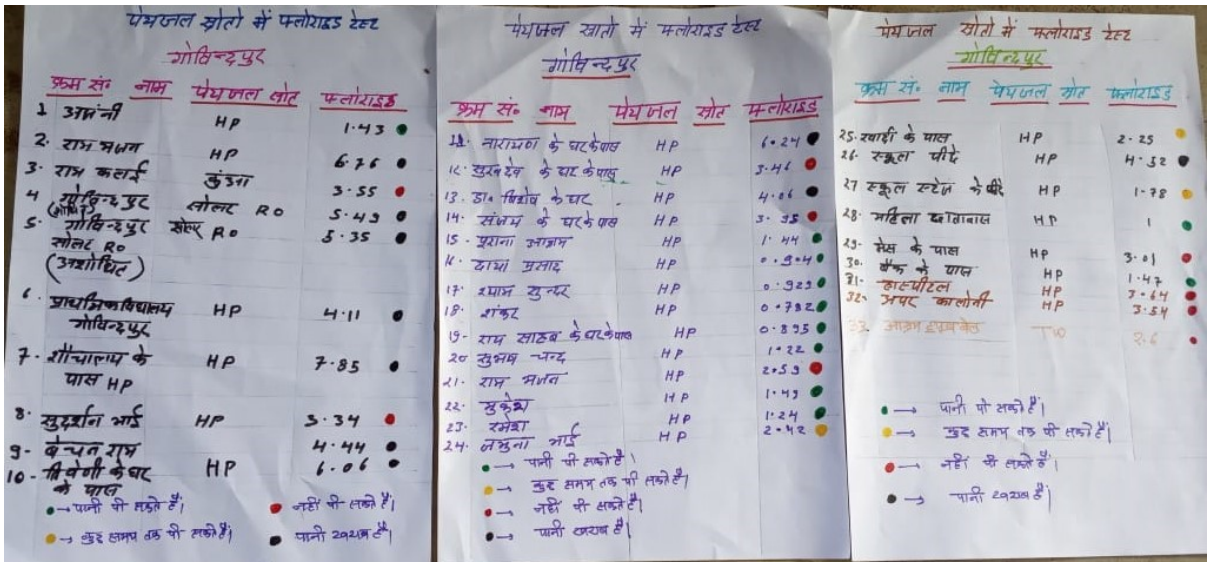


Fig 6 Govindpur village

Drinking water sources colour marked with green, yellow, red and black showing the level of fluoride.

Green- safe

Yellow- under danger

Red- can not be consume but can be use for other uses like agriculture

Black- can not be use either way

Selection of 100 affected Households for study:

On the basis of health survey, drinking water dependency survey and urinary fluoride data, we have selected 100 households including 6 controls HHs. Each members of the family were examined carefully at Arogya Kendra. 94 seriously affected persons were then selected for further interventions.

<u>Criteria for selection of 100 affected persons from Kushmaha and Govindpur</u>

1. Dental and skeletal fluorosis symptoms
2. Drinking water dependency
3. Urinary Fluoride

Obtained data are summarised in Table 5.

Table 5

S N	Criteria of selection	Number of Persons
1	Dental and skeletal Fluorosis symptoms	**59**
2	Drinking water dependency (still drink water having fluoride beyond the permissible limit)	**18**
3	Urinary Fluoride concentration	**17**
4	Control (Using safe drinking water, low urinary fluoride and no symptoms of Fluorosis)	**6**
	Total	**100 Persons**

Medical test data of selected persons are summarised in Table 6

Table 6: Medical test data details

S N	Medical test	Range obtained in test	Standard
1	RBS	**82-399**	90-150 mg/dL
2	Haemoglobin	**8-14**	Male 14-16gm/dL; Female 12-14 gm/dL
3	ESR	**12-51**	Male 19 mm/ first hour; Female 20 mm/ first hour
4	Uric acid	**3.5-7.53**	Male 3.4-7.0 mg/dL; Female 2.5-6.0 mg/dL
5	Serum Calcium	**7.32-11.2**	8.5-11.0 mg/dL

Observations and further work on the data given in Table 6:

We have explored initial medical test data in the month of January and February especially for the cases in anaemia, blood sugar (RBS), ESR (erythrocyte sedimentation rate), uric acid and serum calcium. On the basis of report we then immediately started the nutritional and medical interventions for the needy people.

We surprisingly found that fluoride affected persons were showing normal range of serum calcium. Now again we retested few people in the month of August from our selected list. We found the exact reason of the normal range of calcium and uric acid among the fluoride affected people in the month of January. This area celebrates a famous festival called **Makar Sakranti** and used enormous **til ladu (Sesame seed)** which is rich in calcium. That's why we again rechecked and retested some affected persons and observed lower level of serum calcium (data given in table 8).

It is also reported elsewhere in peer review research articles that the electronegative nature of fluoride has high affinity with electropositive calcium and deposited as calcium fluorapatite

crystals. Certainly the results may be pre- assumed for fluoride affected people in test. Now it is clear and evident from the serum calcium and uric acid report.

In the month of January-February, a list of 100 affected persons was chosen to investigate the relationship between severity of fluorosis and fluoride in drinking water along with the sign & symptoms of affected people.

Average fluoride concentration in drinking water corresponding to different degrees of severity of fluorosis were calculated and shown in fig 7.

We observed that serious skeletal cases were also suffered with doubtful dental Fluorosis.

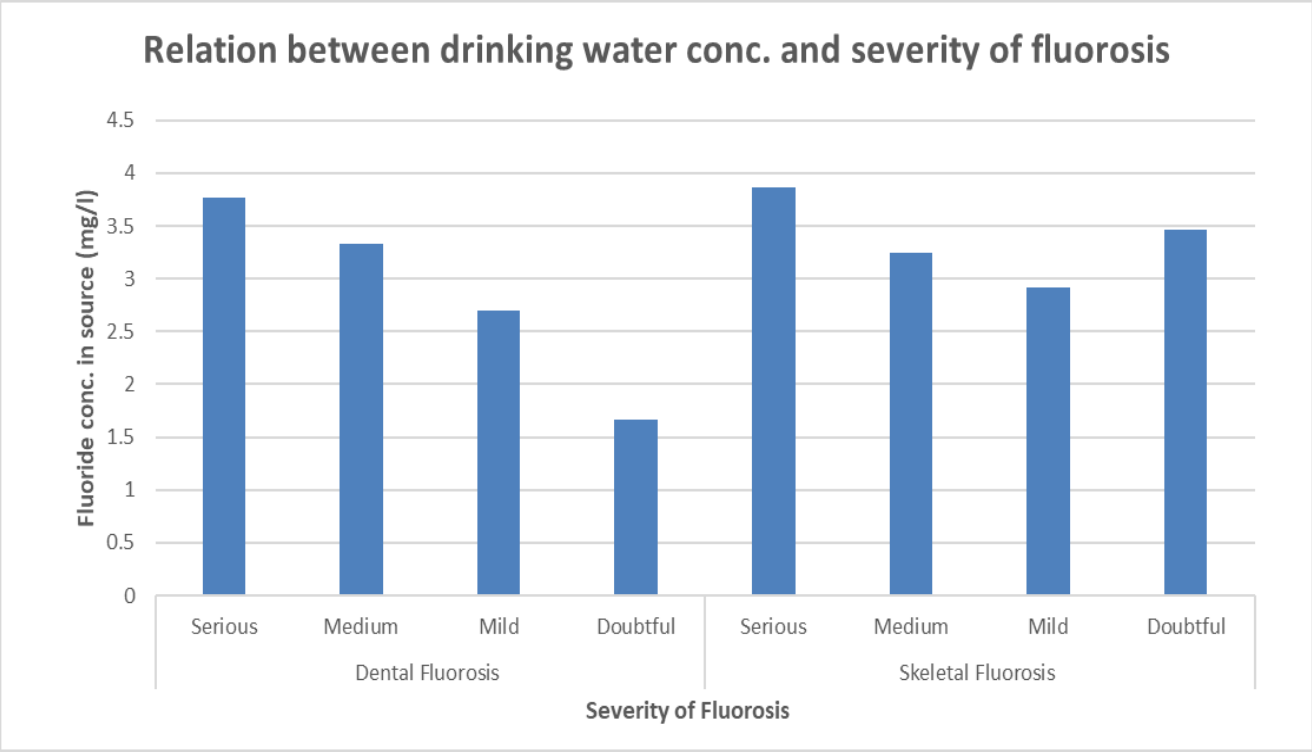


Fig 7 Relation of different level of fluorosis and fluoride concentration in drinking water among 100 people

Fig 8 is depicting the direct relation of urinary fluoride with degree of severity and relates well with affected persons.

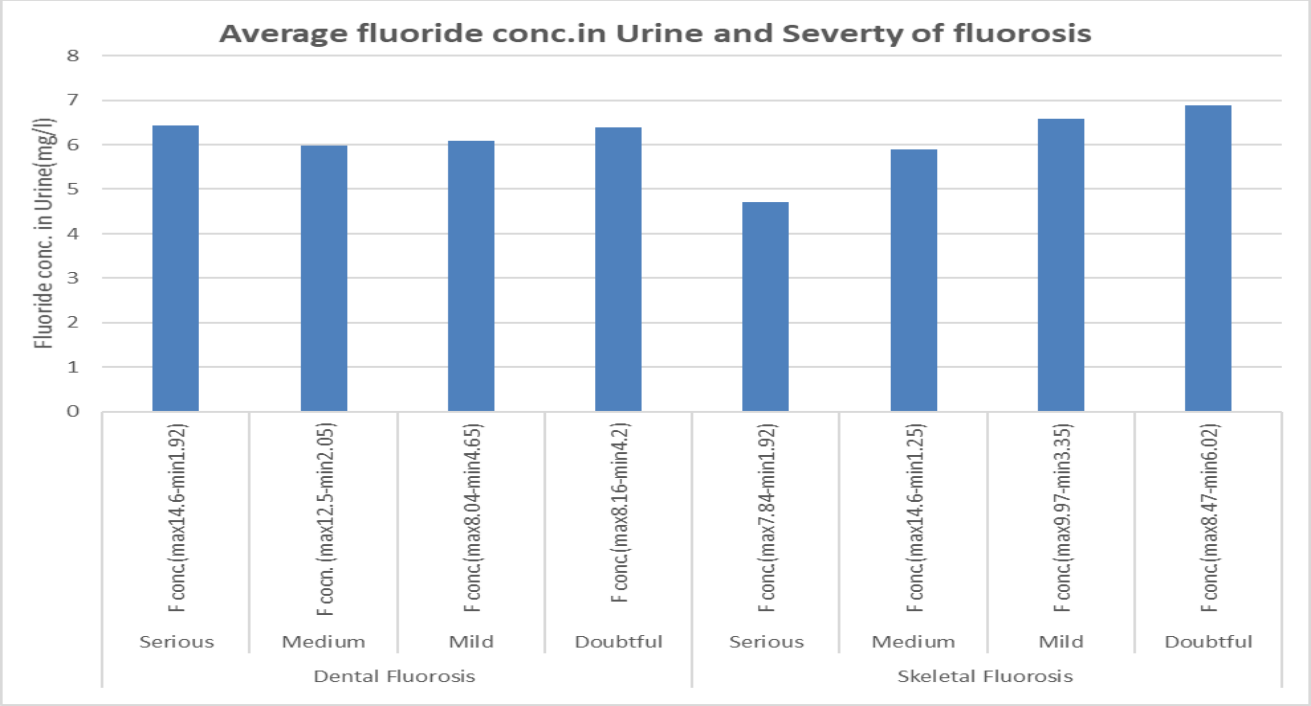


Fig 8 Relation of different level of Fluorosis and urinary fluoride concentration among 100 person list

Surprisingly there is unusual pattern in urinary fluoride concentration corresponding to fluoride concentration in drinking water sources as shown in fig 9.

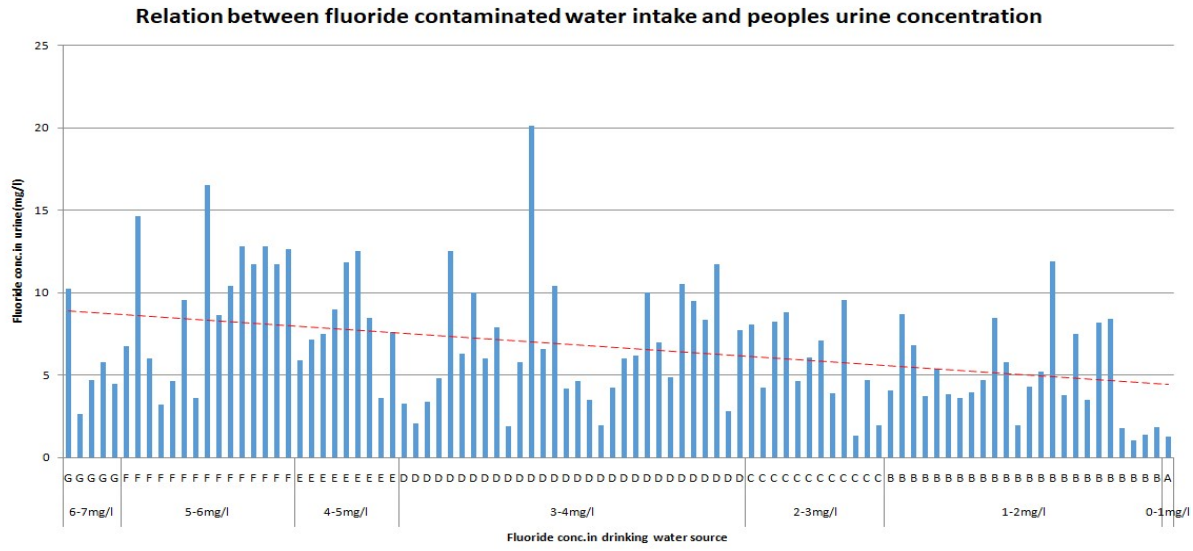


Fig 9 showing correlation of urinary fluoride concentration with intake of fluoride contaminated water

It was observed that urinary fluoride concentration decreases with the decrease of fluoride

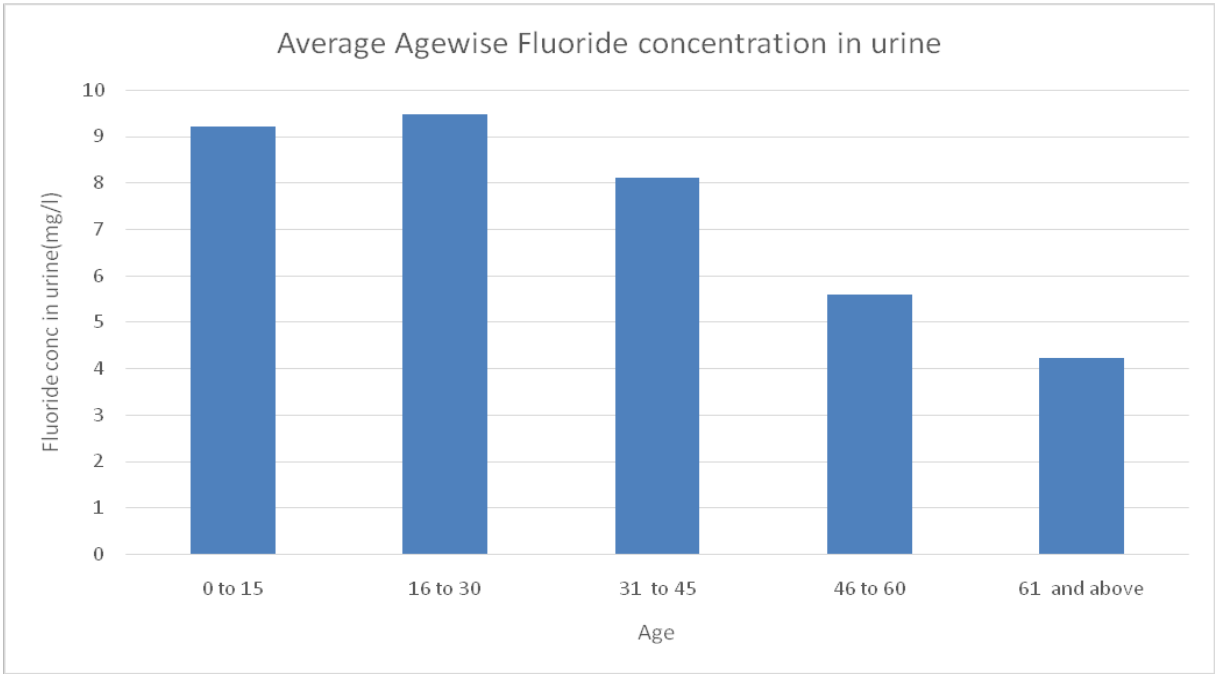


Fig 10 shows urinary fluoride concentrations among different age groups

concentration in drinking water sources.

Fig 10 shows age wise distribution of selected and affected persons with their urinary fluoride. Age range from 0 to 61 years was found to have significant urinary fluoride concentration.

The data from figure 9 and 10 shows the fluoride intake in body may be dependent on other dietary sources or else. That's why people using normal water sources excrete high fluoride and lesser deposition in bones (Bhowmik *et al* , 2019, Current Science, Vol 116, No 9). With age wise also prolonged exposure may result in deposition of fluoride in bones and then lesser excretion.

All these data strengthen our observations and helps in selecting 100 affected persons in both the villages.

Following activities were initiated and interrupted due to the COVID lockdown in March-June period

Phase 1 deliverables were interrupted during the period from March to June due to COVID lockdown in India

Following table are the interrupted deliverables of phase 1 and their status and detailed report is given below in table 7:

Table 7:

S.No.	Activities/ Deliverables	Status
1	Comparative study of 20 Watsan and 5 AA kits in 25 families (from our 100 selected HHs) and Annual Report (September 2020- August 2021)	Completed and report submitted in August month
2	Serum Calcium re-test for 5 people to see the impact of Til laddu (Calcium rich) eating during Makar Sakranti	Completed in August month
3	X-ray test for the 11 persons severely affected with skeletal fluorosis	Completed in August month
4	Monitoring and seasonal water quality test for Fluoride, pH, TDS, Alkanity, Hardness etc of all the drinking water sources in Govindpur and Kushmaha Village	Completed in September month
5	Urinary Fluoride test for 30 people those were successfully established Poshan Vatika and used regularly in food during COVID Lockdown (30 Poshan Vatika were established in March month before lockdown)	Completed in September month
6	Urinary Fluoride test for 25 people where we did the comparative study between Watsan and AA kits	Completed in September month
7	Meeting with health friends and peoples in both the villages, Awareness, motivation and discussion with data	Completed in October month
8	Nutritional aid like Laddu of Til:Methi/Pea nut: Jaguar to the affected people, promotion and training of its making	Started in October
9	Serum phosphate and alkaline phosphatise test for 30 people having high urinary fluoride and control X-ray for 6 people and X-ray of 3 people (from our list of severely affected skeletal fluorosis that need to be done)	Completed in October month
10	Medical supplements for affected people	Started in October month
11	Nutritional seed distribution and establishment of 100 Poshan Vatika (in selected 100 HHs)	Started in October month
12	Distribution and Installation of 74 Watsan kits (in selected 100 HHs)	Installed in first week of November month
13	Home visit and monitoring of use of Installed kits, status of Poshan Vatika, requirement of medical help, regular use of nutritional supplements etc. # two hospital staff and village health friends are doing that 2-3 visit/month/selected HHs with record logbook to note the observations	Started in 3rd week of November month as planned for Phase 2 is started
14	Monthly Fluoride test for filtered water from each installed kit	Started in last week November month

1. Comparative study of 20 Watsan and 5 AA kits in 25 families (from our 100 selected HHs):

1.1 Installation of Defluridation Kit

We have demonstrated the WATSAN and AA kit in front of selected HHs in March month but due to COVID time community approach became difficult and we could not be able to pursue that. So, comparative study of defluridation kits was started in July 2021 that includes 20 WATSAN and 5 AA kits. This was suggested by PPI in the month of March and we studied it. Detailed report on the performance of both the kits has been submitted to PPI August 2021.

1.2 Comparative Study of Fluoride Removal Kits: Between Watsan and Activated Alumina kit

In the month of July when the lockdown slowly lifted up, we started the research work based on queries raised by PPI for the selection of fluoride removal kits (WATSAN and Activated Alumina Kit).

We have selected 25 families sample size for small research work to find out the efficacy and handling of the kits among the fluorosis affected families in the selected villages.

1.3 Findings of Comparative study on WATSAN and Activated Alumina kit:

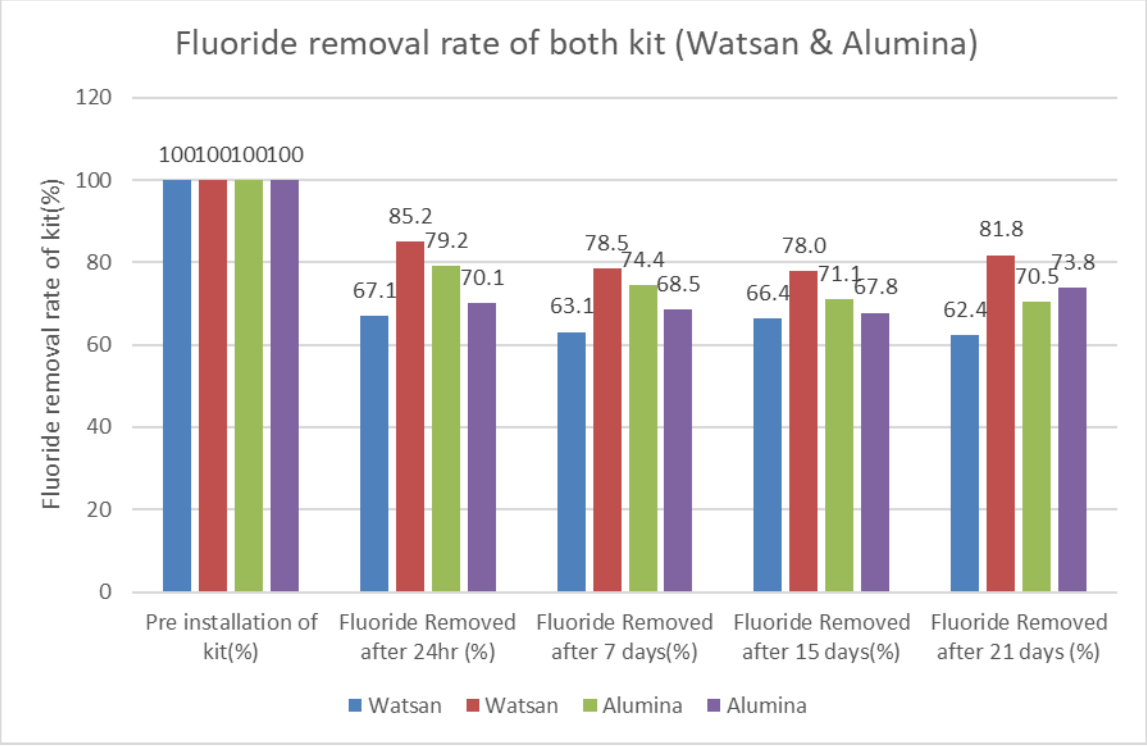


Fig. 11: comparative efficacy test for both kits

We considered all the necessary parameters for the study of both watsan and alumina kits. 25 kits were then distributed among 25 families in the selected villages.

We studied the efficacy of fluoride removal kits and considering 2 kits for both as we can see in the **figure 11**. Both the kits work well in the range of >60-85% in the removal of excess fluoride to the value of prescribed limit of drinking water (1.5 ppm) as per the standard. The range of fluoride removal capacity seems to be constant till 21 days in our study (pH range 7.2-8.5). Watsan kit removes 65-85% excess fluoride in 24 hours while Alumina kit removes 65-80% in 24 hr.

In case of our concern about the efficacy of both kits under different fluoride sources, we have applied source fluoride with range of concentrations from 3-5.9 ppm for both the kits as shown in **figure 12**. We found both the kits work well under the pH range 7.2-8.5. This study gives an idea about both the kits that can remove excess fluoride up to the prescribed limits in 24 hours.

Somehow we also feel initially that people unable to monitor exact 24 hr incubation time for the Watsan kit and we observed slight variations in fluoride concentration in their filtered water but later they became comfortable in caring the time limit of incubation.

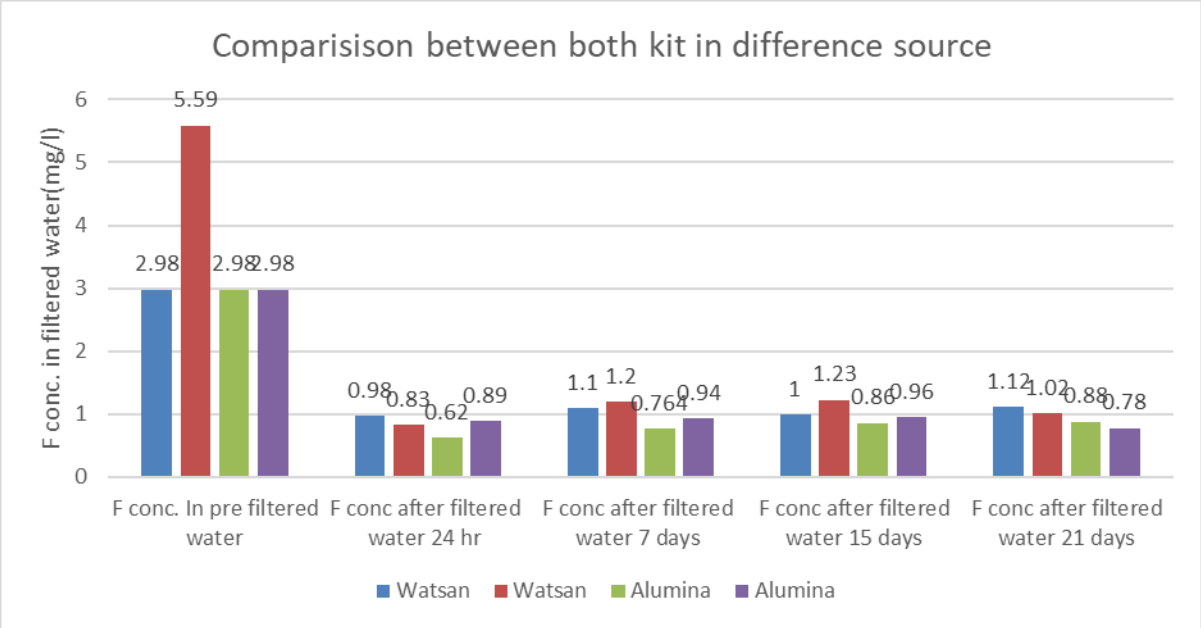


Fig.12: Comparative study of both kits for the different source fluoride and for their fluoride removal capacity.

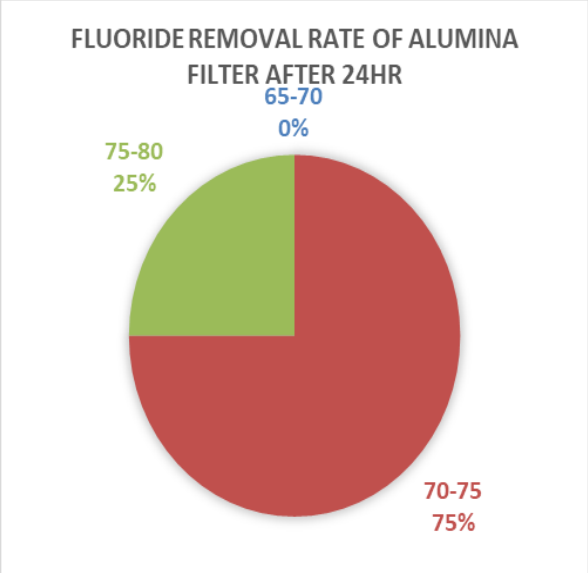
We, in our study for the all the alumina and watsan kits, all the kit's functioning well and all were monitored regularly up to the 21 days from the day of installation and its uses by the community.

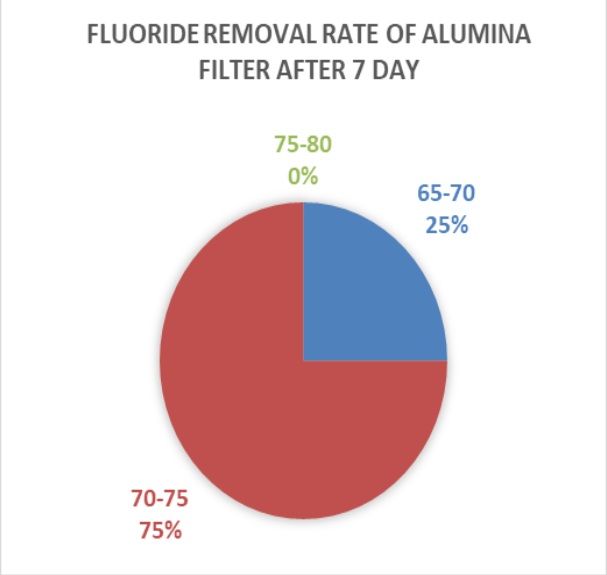
1.4 Detailed study of Activated Alumina Kit:

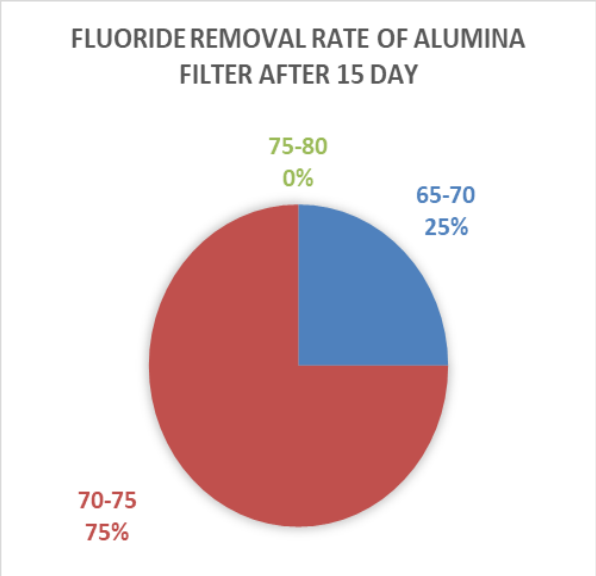
Figure 13 gives the detailed idea of Alumina kit functioning in removing the excess fluoride from the contaminated water. 75 % kits work with the efficiency of 70-75 % fluoride removal in 24 hours while 25 % kits remove 75-80 % Fluoride from the source water. Gradually, in 7 days data showed 75 % of the kits still remove 70-75% fluoride while 25% of the kits get down in the removal of fluoride up to the 65-70% which also remains same for further 15 days. After 21 days, only 50% of the kits show 70-75% fluoride removal while rest 50% of the kits show 65-70% fluoride removal.

1.5 Observations:

1. The trends give an idea of the need of recharging the alumina matrix in future. Among the distributed kits, it is required to monitor all the kits monthly and 50 % kits may be required recharging in 4-6 months from the installation. Also we monitor the flow rate of the water; it is observed that flow usually get down after few days of installation and cleaning of porous plate need to be done weekly. In addition to that cleaning of bucket is found to be difficult; it can be done during the recharge of alumina.







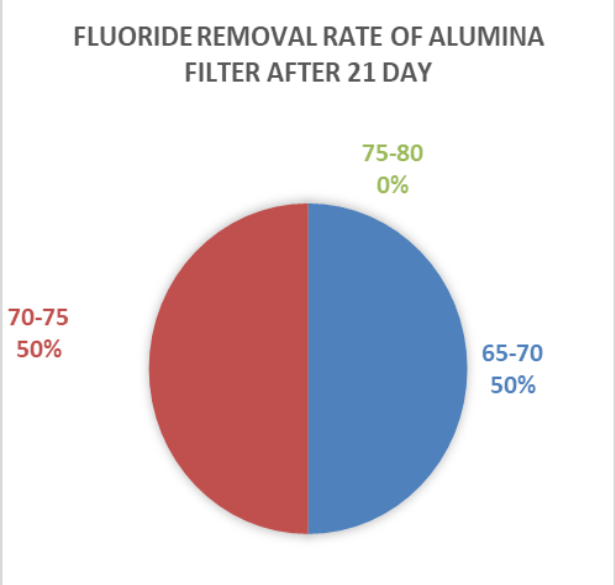


Fig. 13: Regular monitoring of distributed Activated Alumina Kits:- the data shown in Pie charts reveal that 50-75% of kits remove 70-75% fluoride

2. People liked the taste of water, transparent and odourless.

3. People felt the improvement in digestion and gastric problems.

4. The kit doesn't require any incubation of input source water with matrix, so they just pour the source water and use the filtered water immediately. Filtered water is enough for the cooking their food and for the drinking.

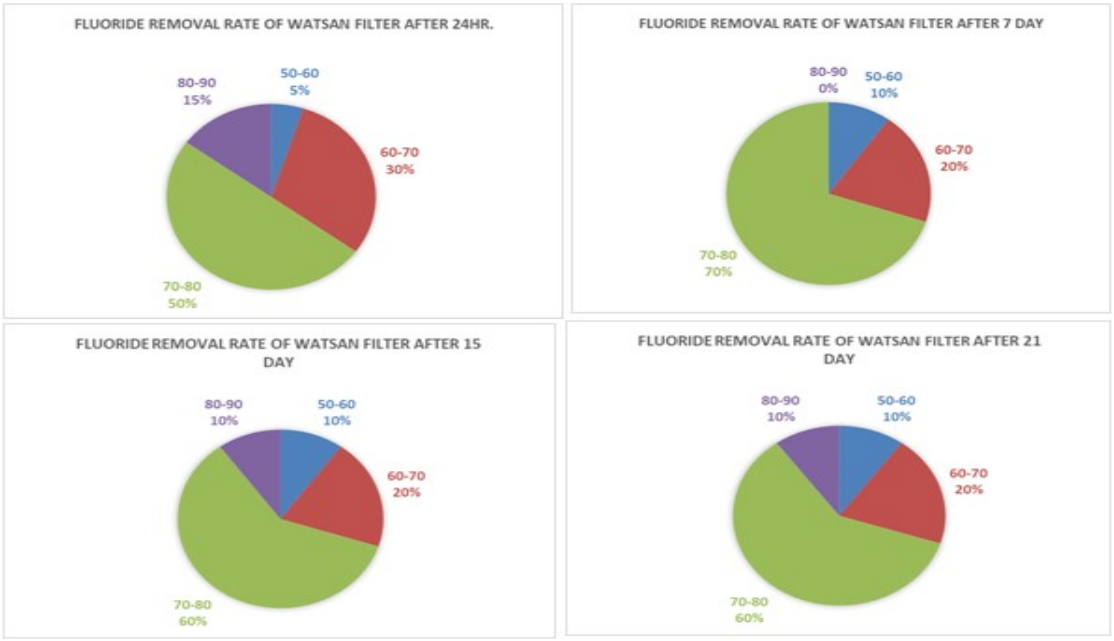
1.6 Detailed Study of WATSAN Kit:

In **figure 14**, we regularly monitor the distributed watsan kits and collect the observations in terms of fluoride removal capacity and user's observations if any. This kit have additional advantage of having another blue kit for the removal of germs and other heavy metal toxicity in source water along with white kit for the removal of excess fluoride in source water.

50 % of the kits remove 70-80% fluoride, 30% kits remove 60-70%, 15 % kits showed best removal which is 80-90% while 5 % kits remove 50-60 % fluoride from the source water. After 7 days, 70 % of the kits remove 70-80 %, 20 % kits remove 60-70 % fluoride while 10 % kit remove 50-60% fluoride.

Frome the 15 days and 21 days data, it reveals that 60 % of the kits remove 70-80% fluoride, 20 % of the kits remove 60-70% fluoride. Again 10 % of the kits showed 80-90 % fluoride removal while 10 % of the kits showed 50-60 % .

Fig. 14: Regular monitoring of distributed Watsan Kits:- the data shown in Pie charts reveal that 50-70% of kits remove 70-80% fluoride



Variation in fluoride removal capacity has been observed in the case of WATSAN kit, 10-15% kits gave us best efficacy in the fluoride removal although only 50-70% kits showed 70-80% fluoride removal ability. Such variations that we observed because of the 24 hr time line incubation in fluoride removal bucket which is somehow not taken care by family members. Slowly the people get attentive for the use of kit.

1.7 Observations:

1. Watsan kits work well in the pH range 7.2-8.5 as well.

2. Variations have been observed in fluoride removal percentage in the modrate and much frequent range of source water fluoride which is 3-5.9 ppm. It's because of the 24 hour time line incubation which users must be followed which seems not to be followed carefully. Further data analysis reveals the fact that people became more careful about the incubation time and fluoride removal percentage increased (up to 90%) and remained constant till 21 days in the range of 70-85%. Importantly, this kit also works well in high concentration of source fluoride in our study.

3. Monthly monitoring is required and correct time for change of matrix may be stipulated. Present data shows the kit will be working well till next 8-10 month. Few kits (20%) may require change of matrix which also needs to be done in next 6 month or more.

4. Filtered water is transparent, odourless and tasty.

5. People felt improvement in digestion, No gastric issues which persist in past, and relief in body pain.

6. Initially people unable to manage the timing and cycle to get fluoride and other contaminant free water by using watsan kit but later they all feel comfortable and get enough water for cooking and drinking purpose.

1.8 Our Field people's observations during community interaction:

Our core working team has observed that few people completely stopped the use of installed RO in village and filtered water from outside sources. Although both the kit works well but people preferably choose watsan kits over alumina kit. It is also very easy to clean the matrix as well as bucket weekly. They did not observe any chocking issues with the kit.

. We also observed the efficacy and community handling as well as all the process of cleaning and need of recharge time for both the kits. In this study, we observed people feel comfortable with watsan kit which also perform compare to AA kits. So we have ordered rest 74 kit**s.**

2. Comparative study of blood serum calcium and uric acid test which we have done in Jan-Feb: Serum Calcium re-test for 5 people have performed to see the impact of Til laddu (Calcium rich) eating during Makar Sakranti

As we have already discussed it in the above section and these test is really required for the clarification.

Table 8: Effect of Makar Sakranti- a festival when people use excess til laddu

S. No.	Name of person	Test conducted in January month (Makar Sakranti festival)		Test conducted in August month Std: Uric acid Male 3.4-7.0 mg/dL; Female 2.5-6.0 mg/dL Serum Calcium 8.5-11.0 mg/dL	
		Uric Acid (mg/dL)	Serum Calcium (mg/dL)	Uric acid (mg/dL)	Serum Calcium (mg/dL)
1	Chameli (F, age-40 yrs)	6.29	10.78	3.09	6.61
2	Panmati (F, age-56 yrs)	5.02	10.54	7.17	5.81
3	Rama (M, age-50 yrs)	4.08	11.69	3.81	5.87
4	Prabha Devi (F, 52 yrs)	5.24	10.87	2.81	6.82

Findings ensured us the lower concentration of serum calcium in the affected people. That's why they need calcium supplements. And thus installing watsan kit provides one extra attribute to supply calcium in traces.

3. X-ray testing of skeletal fluorosis: X-ray test for the 14 persons severely affected with skeletal fluorosis and for the 6 controls

X-ray test is done for the 14 serious skeletal cases and for the 6 controls from our 100 most affected list people. It will clearly help us to figure out the impact of excess fluoride on their bones. Specific points for observations have decided for X-ray test on the basis of their statements. . Then, a clear picture was drawn for the seriousness of skeletal fluorosis in the area. The details are summarised below**.**

Table 9: X-ray data details of fluoride affected people

S No	Name of persons	Village	Sex	Age	Position of X-ray Test	Observations	Remarks
1	Radhekrishna	Govindpur	M	48	Right side AOV	Head of humerous and distal end of clavical osteoporite	Due to low calcium level
2	Chameli	Govindpur	F	40	Knee Joint AP	Osteopenic and patellar erosion	Deposition of fluoride in soft tissues
3	Fallu	Govindpur	M	62	Knee joint AP	Osteophytes formation of left knee joint and sclerosis of distal femur bone	Sclerosis and Entheshmophytes-due to deposition of calcium fluroapetiite in soft tissues
4	Chun kunwar	Govindpur	F	55	Elbow AP and lateral + Pelvis AQL	Osteoporosis of humerous bone and proximal end of radio-ulna bone	Fluoride deposition in soft tissues
5	Chandtara	Govindpur	F	35	Knee joint AP	Osteoporetic knee joints and erosion	Fluoride deposition in soft tissues

						of patella	
6	Vikash	Kushmaha	M	40	Knee joint AP	Tibial head is eroded and osteopenic knee joint	Fluoride deposition observed
7	Ram sevak	Kushmaha	M	51	Knee joint AP	Tibial head is eroded and osteopenic knee joint	Fluoride deposition in soft tissues
8	Chedi Ram	Kushmaha	M	50	Knee joint AP	Tibial head is eroded and osteopenic knee joint	Deposition of fluoride in soft tissues
9	Sukumari	Kushmaha	F	48	Knee joint	Tibial head is eroded and osteopenic knee joint	Due to deposition of fluoride
10	Fulwa	Kushmaha	F	55		Osteopenic and some osteophytes	Due to the fluoride deposition
11	Sunita	Kushmaha	F	35	Knee joint AP	Patella osteoporite and eroded knee joints and osteopenic	Due to the fluoride deposition
12	Baldev	Kushmaha	M	18	Knee joint AP	Osteopenic and some osteophytes	Due to the fluoride deposition
13	Rajan	Kushmaha	M	7	Knee Joint AP	Eroded knee joints and osteopenic	Due to the fluoride deposition
14	Kalawati	Kushmaha	F	70	Knee joint AP	Osteopenic and some osteophytes	Due to the fluoride deposition
15	Control1 Santoshi	Govindpur	F	25	Knee joint AP	Normal	-
16	Control 2	Govindpur	F	20	Knee Joint AP	Noormal	-

	Puja						
17	Control 3 Ram naresh	Kushmaha	M	62	Knee Joint AP	Normal	-
18	Control 4 Devkaran	Kushmaha	M	60	Knee Joint AP	Normal	-
19	Control 5 Utkarsh	Govindpur	M	7	Knee Joint AP	Normal	
20	Control 6 Aanchal	Kushmaha	F	7	Knee Joint AP	Normal	-

Figure 15 showing X-ray of skeletal fluorosis in the affected people

We observed osteoporesiss, osteopenic, sclerosis and osteophytes formation along with they all have bone deformations with restricted mobility. We investigated in literature and find all these must be the reason of deposition of fluoride in soft tissues. Yu-e Song *et. al* 2011 (Environ.

Health Prev. Med, 16: 158-163) studied the effect of fluoride exposure on bone metabolism indicators serum alakaline phosphatase (ALP), Bone alkaline phosphatase and osteocalcin, there they mentioned that serum alakaline phosphatase (ALP) is a marker of bone formation and ALP activity decreased with prolonged exposure of fluoride; short exposure with low fluoride level will increase the ALP activity. So we have planned to perform ALP test of seriously affected people.

4. Serum alkaline phosphatase test for 30 people having high urinary fluoride (6-14.6 ppm)

Serum alkaline phosphatise (ALP) is an important reference indicators for diagnosing bone metabolism changes resulting from fluoride exposure. Huang *et. al.,* 2007 (Med. Sci., 42: 55-57) studied fluoride exposure on the ALP activity in human and stated that ALP activity increases with exposure of fluoride but prolonged exposure decreases the ALP level probably due the enzyme binding by fluoride.

Table 10: ALP test data

No of persons	Normal range (U/L)	ALP (U/L)	Remarks
	Males: 53-128 Females: 53-141		
16		31.57-49.56	10 males and 6 females
3		54.31-57.32	1 male and 2 female
5 + 5 control		60.13-138.57	5 male and 5 female
1		181.92	Vimla Devi, age 43

16 people have decreased ALP activity thus they may have prolonged exposure of fluoride while 3 people showed borderline decrement in ALP level. 5 persons including 5 controls showed normal range. Only one person showed remarkably increase in ALP level which means that Vimla devi have received short but constant exposure of fluoride.

5. Monitoring and seasonal water quality test for Fluoride, pH, TDS, Total Alkalinity, Total Hardness, Calcium hardness and magnesium hardness of all the drinking water sources in Govindpur and Kushmaha Village

These quality parameters were checked in drinking water sources as proposed it quarterly. Due to COVID lockdown we were unable to do that. In September we performed the various water quality tests.

Govindpur and Kushmaha Village: total 33 drinking water sources in Govindpur and 86 sources were tested for the various water quality parameters. The finding is compared with the test done in Feb 2021.

Table 11 showing various water quality parameters in Feb 2021 and Sept 2021:

Findings in Govindpur Village

pH range		TDS range		Total Hardness range		Total alkalinity range		Calcium hardness range		Magnesium Hardness range		Fluoride range	
Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021
7.1-7.8	6.7-7.8	219-581	178-607	42-368	38-398	44-112	40-108	32-108.8	31.8-102.8	5.76-21.12	3.84-23.04	0.8-6.76	1-7.85

Findings in Kushmaha Village

pH range		TDS range		Total Hardness range		Total alkalinity range		Calcium hardness range		Magnesium Hardness range		Fluoride range	
Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021	Feb 2021	Sept 2021
6.9-8.0	6.8-8.1	205-433	165-510	40-400	49-421	16-76	20.2-81.3	32-99.2	34.4-100.6	5.8-42.6	5.6-39.4	0.6-7.26	0.8-8.2

Permissible limit as Bureau of Indian standard (10500:1991) specification for drinking water

1. pH- 6.5-8.5
2. TDS (mg/L)- 600
3. Total Hardness (mg\L)- 200-600
4. Total Alkalinity (mg/L)-200-600
5. Calcium (mg/L)- 75-200
6. Magnesium (mg/L)-30-100
7. Fluoride (mg/L)- 1.5

The data shown in table 11 reflects the data in permissible limits for pH and TDS while few sources in both the village are showing lower value even from the minimum limit. Total hardness (5-10 sources); Total alkalinity (All sources); Calcium hardness (13 sources in Govindpur and 36 sources in Kushmaha) and Magnesium hardness (all the sources of Govindpur and 46 sources in Kushmaha) for these lower values were observed. It is necessary to investigate further and monitor these parameters in next seasonal water quality test.

Water sources from Govindpur village shows fluoride in range of 1-7.85 ppm in Sept 2021 while it was 0.8-6.76 ppm in Feb 2021. In Kushmaha village fluoride in water sources ranges 0.8-8.2 ppm in Sept 2021 while it was 0.6-7.26 ppm in Feb 2021. With the help of community people water sources having high fluoride concentration were marked as black and mentioned as “Not for use for any purposes”. Increased fluoride concentration is due to the post-mansoon effect and also air pollution may play a significant role in adding fluoride to the water sources.

6. Urinary Fluoride test for 30 people those who were successfully established Poshan Vatika and used regularly in food during COVID Lockdown (30 Poshan Vatika were

established in March month before lockdown and Urinary Fluoride test for 25 people where we did the comparative study between Watsan and AA kits

We have organised a community meeting in January for the establishment of Kitchen Garden (Poshan Vatika) to provide dietary requirement to combat fluoride problem. Also we motivated many affected people including our selected 100 HHs for nutritional interventions. Around 30 kitchen gardens have established in the selected HHs and include leafy vegetables as a priority (Spinach, Chulai,) as well as Bhindi, Bottlegaurd, Cucumber etc.

Although villagers raised major problems of free grazing cattle in summer which can destroy the garden but they managed and care the vatika.

We could not follow the impact of these kitchen gardens in summer but we performed the urinary fluoride test in both the villages.

We also check the urinary fluoride in 25 people who used either Watsan filter or AA kit for 3 months.

5 people were also selected those avail vegetables from Poshan Vatika as well as used defluoridated water for 3 month.

Table 12: Urinary fluoride test to see the changes after using Poshan Vatika and defluoridation kit

Persons	Urinary fluoride range in Feb 2021	Urinary fluoride in Sept 2021
30 people- used vegetables from Poshan Vatika for 3 month	6.2-12.0	3.4-9.3
25 People used Watsan or AA Kit for 3 month	5.4-16.1	1.4-7.8
5 people used both Poshan Vatika and watsan or AA Kit for 3 month	5.4-16.1	0.8-3.2

We can elucidate it from the data given in table 12 that nutritional interventions along with defluoridated water will significantly lower the urinary fluoride. It reflects the fact that if we minimize the fluoride intake by regulating dietary habit and water will be a promising approach to combat fluorosis. So, cumulative approach is required and further monitoring is going on.

We again established 100 Poshan Vatika and provide good seed e.g. Fenugreek (Methi), Soya, Okra (Bhindi), Turai, Bottle gourd, Carrot, Spinach, Raphanus and Coriander.

Now these interventions will be planned further. And, detailed log book is prepared for the monitoring all the 100 HHs.

7. **Medical supplements and Nutritional aid like Laddu of Til:Methi/Pea nut: Jaguar to the affected people, promotion and training of its making**

We have started giving some medical aid for few people in the month which includes zinc supplements, Iron tablets Vit C and Calcium, Vit E to severely affected symptomatic cases and has asked them to use roasted Til, Methi/Pea nut and Jaguar (Gur) combined as Laddu. We started doing this to demonstrate the importance of nutritional benefits of these items to the sufferer. Also dalia of Ragi millet (Rih in calcium) and laddu of Mahua (rich in Iron and energy) with Til we believe that also provide lot of benefits to the affected persons. Again we were unable to follow the impact of such nutritional activities due to lockdown. So, now such interventions we have started. We gave a short training to 10 people from different tola of both the villages. These trained people then voluntarily spread the message of nutritional benefits and motivating people to make and use these items regularly at their home. Also, our field worker started visiting all the 100 HHs at least twice in a month to monitor them and to provide necessary medical supplements..

8. Distribution and Installation of 74 Watsan kits (in selected 100 HHs):

We performed a comparative study of AA kits and Watsan defluoridation kits in July- August 2021. Based on the analytical observations and community ease on handling during the use, we ordered rest 74 Watsan kits. These kits were demonstrated in community meeting and distributed with their Rs 1000.00 contributions for maintenance and for new candle if required. Our health friends have started constant monitoring of the performance of installed kits. We have planned to test fluoride on the monthly basis in our lab.

Distribution of Watsan defluoridation kits

9. Home visit and monitoring of use of installed kits, status of Poshan Vatika, requirement of medical help and updates about nutritional supplements they use regularly etc.

Two hospital staff and village health friends have started home visit from December 2021. They will visit at least 2-3 visit/month/selected HHs and record the updates in logbook.

Also we recently call a meeting with our core team and PSI people to plan for phase 2 deliverables.

Now, we are at the stage of completion for all the phase 1 deliverables and from the phase 1 findings that encourages us to start regular monitoring and analysis phase. Following activities of phase 2 will be performed in coming months hoping no further COVID LOCKDOWN in INDIA:

1. Regular visit in selected HHs and monitoring kit performance. Motivating people to use nutritious food and if necessary to them, provides medical supplements.

2. Impact Analysis (serum calcium, urinary fluoride, X-ray tests) and seasonal water quality test in February 2021.

3. Health improvement analysis.

4. Awareness campaigning and community meetings will be performed along with planning for water security & conservation of secured water sources.

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