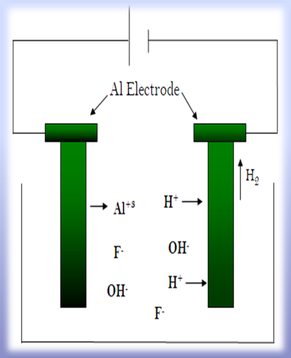
Solar Energy Based Electrolytic Defluoridation Plants

Principle



Reactions during electrolytic defluoridation.

$Al \rightarrow Al^{+3} + 3e^-$

$Al^{+3} + 6F^- \rightarrow AlF_6^{3-}$

$AlF_6^{3-} + 3Na^+ \rightarrow Na_3AlF_6$

$2H_2O + 2e^- \rightarrow 2OH^- + H_2$

$Al^{3+} + 3OH^- \rightarrow Al(OH)_3$

Flow Diagram

Raw Water Tank

DC Power Supply

Solar Panels

Bore Well

Reaction Chamber

Treated Water Tank

Treated Water Taps

EDF plants installed by CSIR-NEERI

Dongargaon, Chandrapur Dist. (M.S.)

Sargapur, Seoni Dist. (M.P.)

Usarwara, Dist. Durg. (C.G.)

Salient Features

- Removal of fluoride by active species of hydroxide of aluminium produced by passing DC power through aluminium electrodes
- Simple to fabricate, easy to operate with minimum maintenance
- Suitable for treatment of raw water with fluoride concentration upto 10 mg/L
- Produces potable water with palatable taste as against the other available chemical treatment methods
- Quantity of sludge produced is much less (60-70%) than conventional treatment methods
- Simultaneous reduction in bacterial contamination in treated water
- Capacity : 2000 L per batch in 3- 3.5 hours
- Cost of treated water Rs. 20 per 1000 liter

Present Status

- Know how transferred to 7 private agencies
- More than 100 plants installed in fluoride affected areas

Awards

International Project Innovation Award (PIA) instituted by International Water Association (IWA)

The DST-Lockheed Martin India and FICCI Innovation Growth Program Award 2012

EDF plants installed by CSIR-NEERI

Adiwasi Kanya Shiksha Parisar , Chindwara Dist. (M.P.)

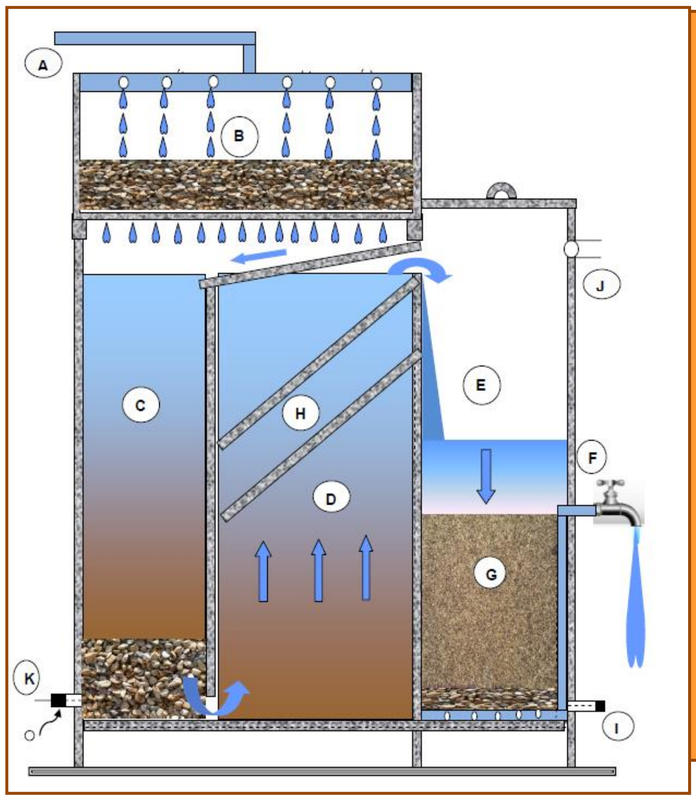
Malgaon, Balod Dist. (C.G.)

Adiwasi Kanya School, Chindwara Dist. (M.P.)

Hand Pump Attachable Iron Removal Plant

Principle

- Aeration (Gas transfer)
- Oxidation
- Precipitation
- Sedimentation
- Filtration



A : Raw water Inlet pipe from Hand Pump
B : Aeration Chamber
C : Flocculation Chamber
D : Sedimentation Chamber
E : Filter Chamber
F : Treated water Outlet Tap
G : Sand Bed
H : Settling Plates
I : Filter Drain Valve
J : Overflow Outlet
K : Flocculation Chamber Drain Valve

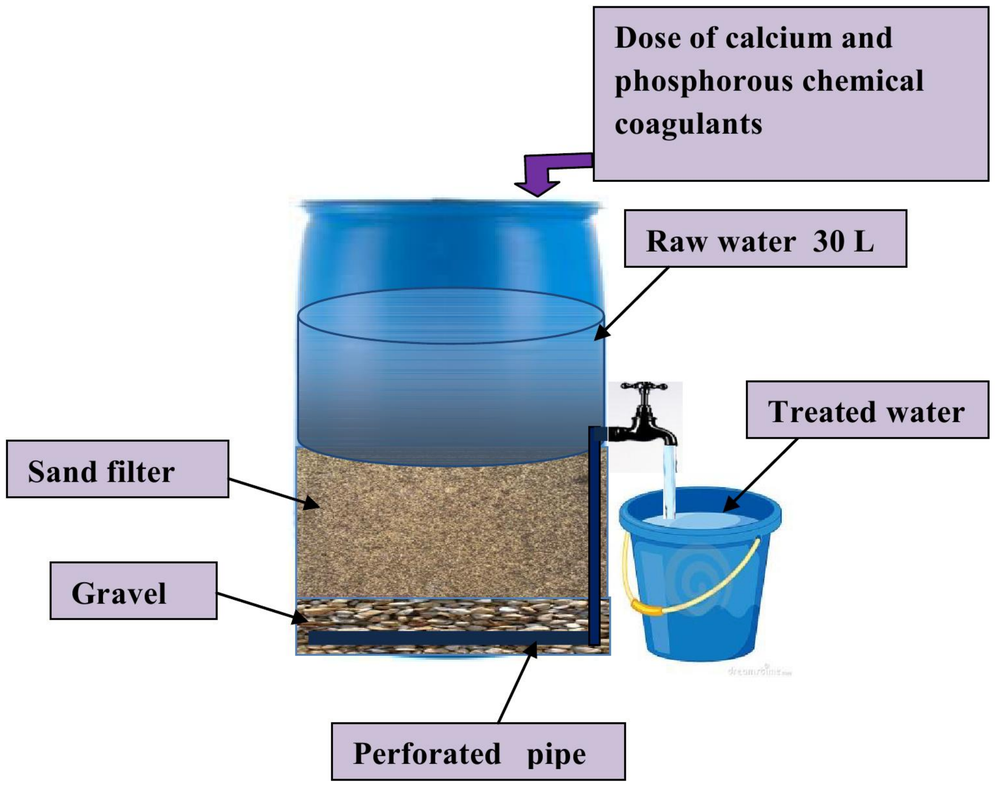
HP attachable Iron Removal Plant – RCC Structure (To be fabricated onsite)

HP attachable Iron Removal Plant – FRP Structure
(Can be fabricated in the factory and installed at the site in a few hours)

Salient Features

- Oxidizes the dissolved iron : 1-30 mg/L
- High Removal Efficiency and easy to operate
- Single Unit System can provide 40 lpcd iron free water to 250 persons and can be installed on existing hand pumps
- No need of chemical addition, skilled operator, electric power and mechanical parts
- Minimum maintenance with negligible operational cost
- Pre-fabricated FRP units can be installed quickly
- 200 plants are already installed by PHED and working efficiently in Iron affected areas in Chhattisgarh State
- System cost : RCC – Rs. 50,000 and FRP - Rs. 90,000
- Selected in DST - Lockheed Martin India Innovation Growth Programme 2013

Chemo - Defluoridation Household Unit



Schematic Diagram of Household Chemo-Defluoridation Unit

Salient Features

- Process involves formation of insoluble fluoride complex with salts of calcium and phosphorous and filtration through sand filter
- Reduces the fluoride concentration in water to <1 mg/L
- A typical unit, of 30 L capacity can serve a family of 5-6 persons, on the basis of 5-6 litres per capita/day for drinking and cooking purposes
- Suitable for treating the water upto fluoride concentration of 10 mg/L
- No leaching of fluoride from sludge back into the water at normal pH range (6.5-8.5)
- Most reliable for small fluoride affected villages where community water treatment plant is not economically feasible
- Unit cost Rs. 3000-4000 and operating cost Rs. 0.20 per litre

Novel Features

- Simple to fabricate and easy to operate
- Minimum maintenance
- Gravity operated
- No power requirement
- Taste of the treated water is palatable
- Typical Capacity - 30 L

Chemo-Defluoridation Units Installed in the Field

Chichkavatha Village, Nagpur District

Sakhara Village, Yavatmal District

Chemo - Dearsenification Household Unit

Salient Features

- Process involves removal of arsenic using Fenton's reagent / $KMnO_4$+ $FeCl_3$
- Reduces arsenic concentration in water to <10 ppb
- A typical unit, of 30 L capacity can serve a family of 5-6 persons, on the basis of 5-6 litres per capita/day for drinking and cooking purposes
- Suitable for treating the water upto arsenic concentration of 2000 ppb
- No leaching of arsenic from sludge back into the water at normal pH range (6.5-8.5)
- Most reliable for small arsenic affected villages where community water treatment plant is not economically feasible
- Unit cost Rs. 3000-4000

Cost of Treatment

With $KMnO_4$ + $FeCl_3$ = Rs. 3.0/1000 litre

With Fenton's Reagent = Rs. 3.78/1000 litre

Novel Features

- Simple to fabricate and easy to operate
- Minimum maintenance
- Gravity operated
- No power requirement
- Taste of the treated water is palatable
- Typical Capacity - 30 L

Chemo-Dearsenification Units Installed in the Field

Kaudikasa Village School , Rajnandgaon District (C.G.)

Kaudikasa Village, Rajnandgaon District (C.G.)

NEERI - ZAR : Portable Instant Water Filter

Novel Features

- Simple to fabricate
- Easy to operate
- Minimum maintenance
- Light weight
- Ease in transportation and installation
- Most Reliable for emergency water supply
- Gravity operated
- No power requirement
- Typical Capacity - 20 L/h.

Salient Features

- Water purification system suitable for potable water supply particularly under emergency situation such as flood and cyclone with a wide range of flood water quality
- Can also be used to treat the pond/lake water for the villages or small colony situated at the isolated places
- A typical unit, with two 100 L vessels, can serve about 20-30 persons, when operated for 10 hours a day, on the basis of 6-10 litres per capita/day for drinking and cooking purposes
- Removes turbidity and suspended matter as well as the micro-organisms:
- Can be used as Domestic Iron Removal Unit
- No change in the dissolved mineral concentrations in raw and filtered water
- Unit cost Rs. 5000-6000 and operating cost Rs. 3 per 100 L
- Technology is available free to everybody who wants to use for societal venture

Awards

International Project Innovation Award (PIA) instituted by International Water Association (IWA)

Nina Saxena Excellence in Technology Award 2008

NEERI- ZAR Units Installed in the Field

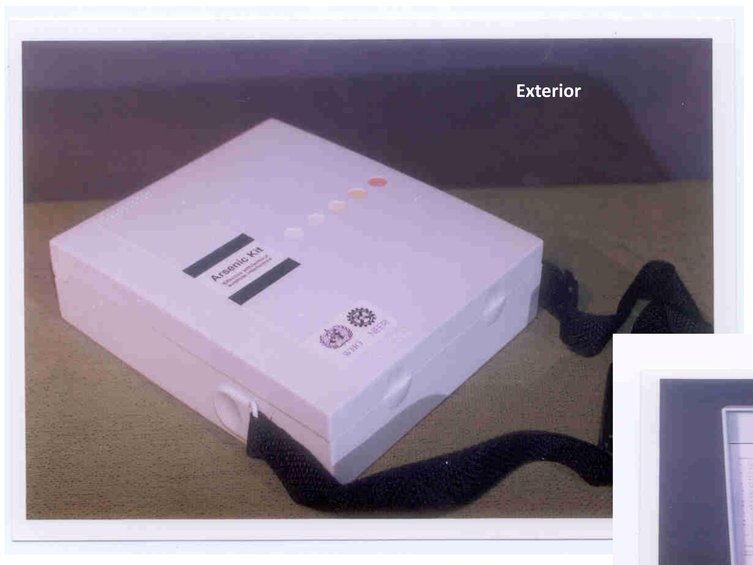
Barmer Dist., Rajasthan - October 2006

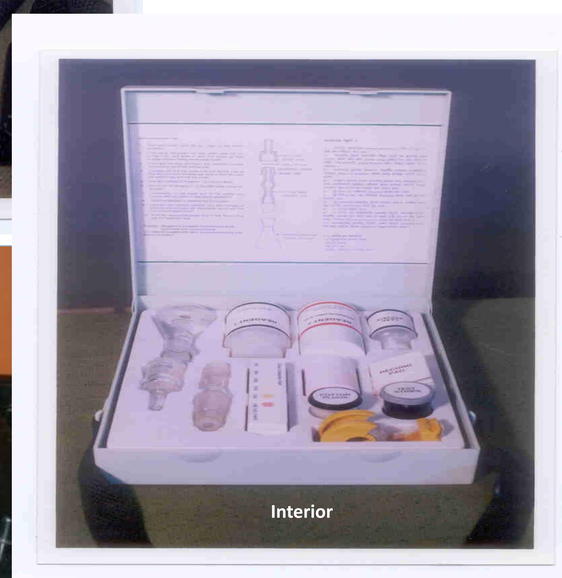
Aila Cyclone affected villages of Sundarban District (West Bengal)-2009

Disaster affected areas of Uttarakhand State - 2013

Domestic iron removal units at Tadoba Tiger Reserve Forest (Maharashtra State) - 2011

Water Quality Test Kits





Arsenic Detection Field Kit

Principle: Based on Mercuric Bromide Stain Method

Salient Features

- Useful for rapid on-site screening of water sources for arsenic
- Detection range : 10 ppb to 1000 ppb
- Precision and Accuracy ≥ 20 ppb
- Aesthetic, Sturdy, Lightweight
- Free from occupational hazards
- Contains arsenic free reagents
- Convenient to carry in the field
- Capacity : 100 tests per kit

Multi-parameter Water Quality Field Test Kit

Parameter	Principle
pH	pH strips colour comparison
Total Hardness	Titrimetric
Total Alkalinity	Titrimetric
Chloride	Titrimetric
Residual Cl (O-Toludine)	Visual colour comparison with standard colour chart
Iron	Visual colour comparison with standard colour chart
Fluoride	Visual colour comparison with standard colour chart
Turbidity	Visual colour comparison with standard colour chart
Nitrate	Visual colour comparison with standard colour chart

The test results obtained by WQFTK are comparable to standard laboratory procedures and the kit is useful for analysis of total nine potential water quality parameters.

Natural Water systems and treatment Technologies to cope with Water Shortages in urbanised Areas in India

NaWaTech

www.nawatech.net

Under the Framework of India-European Union Science & technology Cooperation Project In Water Technology and Management

EUROPEAN UNION

Department of Science & Technology Government of India

NaWaTech Objectives

- To assess and enhance natural and technical water treatment systems in order to develop a technically cost-efficient and robust water management system to cope sustainably with water shortages in India
- To disseminate, exploit and ensure the take-up in practice and mainstreaming of NaWaTech activities and outputs
- To benefit Indian SMEs in the water sector
- To establish foundations of a long – term cooperation between EU and India

NaWaTech Key Deliverables

- NaWaTech Sustainability Criteria
- Compendium of Technologies
- Technological enhancement
- 5 Sustainable NaWaTech sites in Pune and Nagpur NaWaTech Community of Practice
- NaWaTech short film for advocacy and dissemination
- NaWaTech decision support kit based on the elaborated Technical Notes and Policy Briefs (The NaWaKit)
- Conference, trainings, international workshops and Integration of the NaWaTech approach in University Curricula
- 10 SMEs offering the NaWaTech approach in India

Consortium Partners

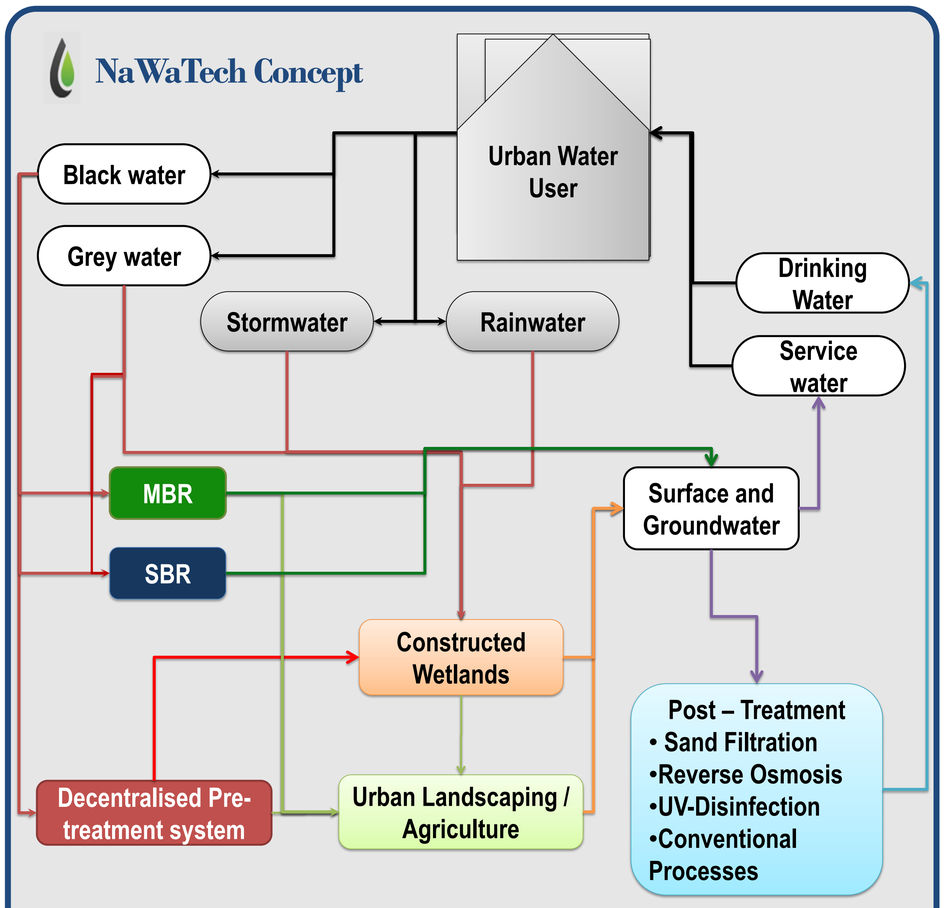
European

ttz Bremerhaven; seecon gmbh; IRIDRA; UPC; kre_ta; BOKU; BIOAZUL

Indian

NEERI; ecosan SERVICES FOUNDATION; (SERI); Indian Water Works Association

NaWaTech Concept

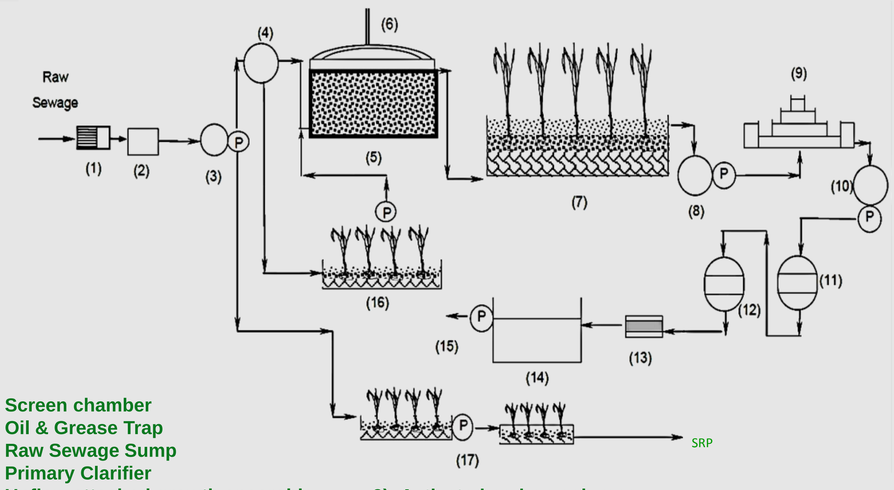


NaWaTech Concept is based on optimised use of different urban water flows by means of multi-barrier approach.

Intermittent urban water sources

Water sources available over the whole year

Treatment Scheme at Ordnance Factory, Ambajhari



1) Screen chamber
2) Oil & Grease Trap
3) Raw Sewage Sump
4) Primary Clarifier
5) Upflow attached growth anaerobic filter
6) Bio-gas vent and collection
7) Subsurface flow constructed wetland
8) Holding Tank
9) Cascade aeration
10) Effluent collection tank
11) Dual media (pressure) filters
9) Activated carbon columns
10) On Line chlorine disinfection
11) Treated effluent collection tank
12) Pumping & Piping for treated effluent reuse
13) Sludge Drying Reed Beds
14) French Reed Beds – 1st & 2nd Stage,
P – Pumps

NaWaTech – CoP, Nagpur Chapter

Public Meeting at Central Railways, Nagpur

NaWaTech COMMUNITY OF PRACTICE

- Key Stakeholders
  - Academia and Research
  - Industry
  - End users
  - Decision Makers in Water & Sanitation Sector
  - Experts from India and Europe
- NaWaTech-CoP Chapters
  - Nagpur Chapter
  - Pune Chapter

Apex Body (7 Indian + 7 European)

Advisors

Local Chapter (Nagpur & Pune)

Secretariat Nagpur @ NEERI Pune @ ESF

Executive Secretary

NaWaTech – CoP Members

NaWaTech Implementation Sites

Ordnance Factory Estate

1. Residential Estate

Location: Ordnance Factory, Ambajhari

Capacity: 100 m³/day (1000 p.e.)

NaWaTech System:

- Water Source - Wastewater from 256 households
- Natural Multi-barrier system including primary treatment, constructed wetlands and disinfection)
- Novel sludge management using sludge drying reed beds (SDRB)
- Treated wastewater reused for watering the Multi-purpose lawn in the colony
- Development of Green belt using short rotation plantation with French reed bed system (FRB)

NIT Garden, Nagpur

2. Common Recreation Areas / Gardens

Location: NIT Garden at Jaripatka, Nagpur

Capacity: 100 m³/day (1000 p.e.)

NaWaTech System:

- Water Source: Wastewater flowing through the near by open drain (Nullah)
- Natural Multi-barrier system including pre-treatment, combination of HF & VF constructed wetlands and disinfection
- Treated wastewater reused for watering the plants and lawn in the garden

Amanora Park Apartment, Pune

3. High Rise Residential Complex

Location: Amnora Park Apartments, Pune

Capacity: 40 m³/day (400 p.e.)

NaWaTech System:

- Water Source: Wastewater generated by the residents
- Part of the flow will be treated in a combination of compact technologies like MBR & SBR
- Treated wastewater reused for flushing and landscaping

COEP Hostel Campus

4. University Housing Facility

Location: Boys Hostel, College of Engineering, Pune

Capacity: 180 m³/day

NaWaTech System:

- Water Source: Wastewater generated in the hostel
- Multi-barrier system for including natural constructed wetlands
- Treated wastewater reused for flushing and gardening

Nullah, Pune

5. Nullha / Open Sewer

Location: Indradhanushva Environment and Citizenship Center, Dattavadi

Capacity: 400 p.e.

NaWaTech System:

- Water Source: Wastewater from the open drain (Nullha)
- Water treatment using EcoBank Filtration
- Treated wastewater reused for gardening

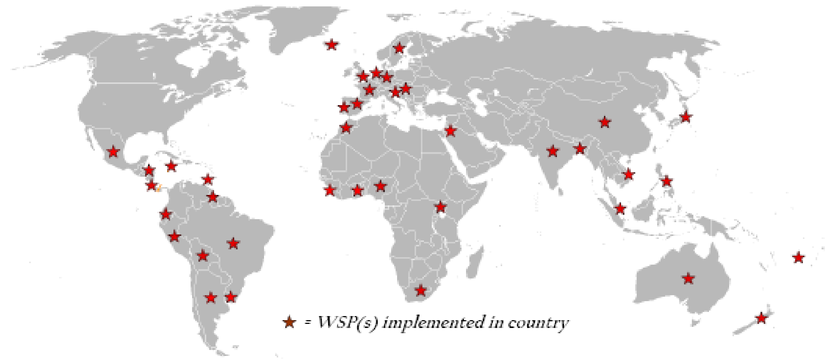
Implementation of Water Safety Plan for Nagpur City

A documented plan that:

- **Identifies** hazards, **assesses** risks from catchment to consumer
- **Mitigates** risks through control measures

Meaning:

- Less **output** monitoring (final water)
- More **input** monitoring (is the system working?)



Development of Water Safety Plan

Identified Hazards

Catchment & Raw Water Sources

Ash pond in the catchment of Kanhan River

Filthy Conditions near Intake of Kanhan River

Water Treatment Plants

Unregulated Flow of PAC Dose at Kanhan Treatment Plant

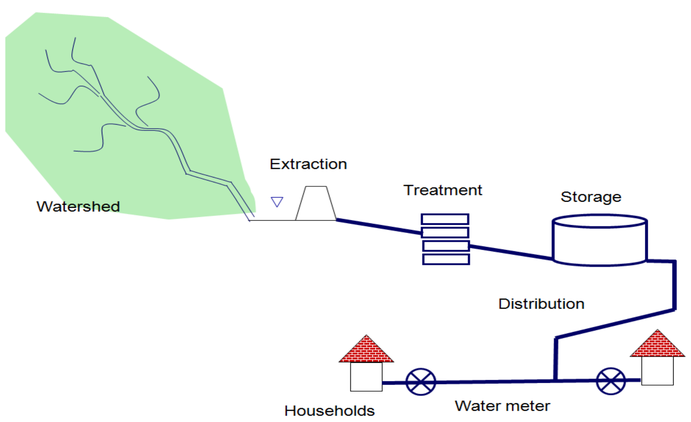
Aquatic Weeds in Clarifier at Old Gorewada Treatment Plant

Service Reservoirs

Broken Inlet Chamber of Master Balancing Reservoir at Seminary Hill

Leakage from Inlet Valve of Master Balancing Reservoir at Seminary Hill

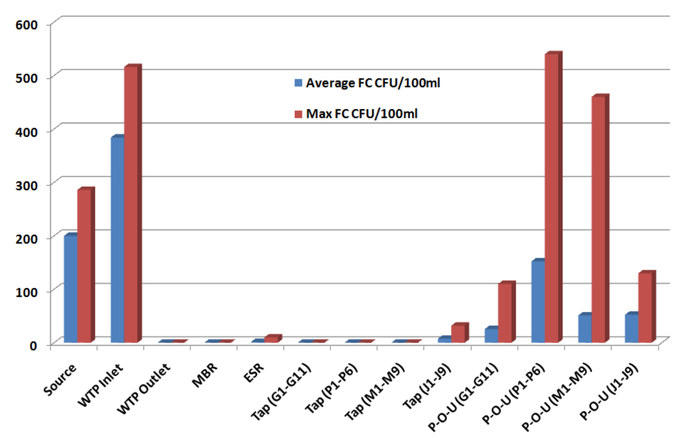
Elements of Water Supply System



Sanitary Survey at Select Households

Question asked	Yes answer
Is storage design for dipping	88%
Do they use dipper with short/no handle	67%
Is the vessel accessible for children	58%
Do they pour back excessive water	43%
Is the vessel made of non-durable material	33%
Do they lack lid on storage vessel	17%
Is the inside of the vessel hard to clean	13%
Are there signs of dirt around opening	11%

Water Quality from Source to Point-of-Use



Implementation of Water Safety Plan

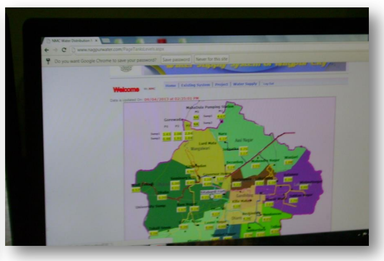
Repair and Rehabilitation works

De sludging and repair of clariflocculators at Pench –II WTP

Fitting of bulk flow meters and HDPE pipes eliminates problem of pilferage

By pass valves installed at Seminary Hills MBR to facilitate cleaning and repair

Laying of pipeline by Horizontal Directional Drilling (HDD)



Online monitoring system gives information about pressure and water levels

Mohalla meeting

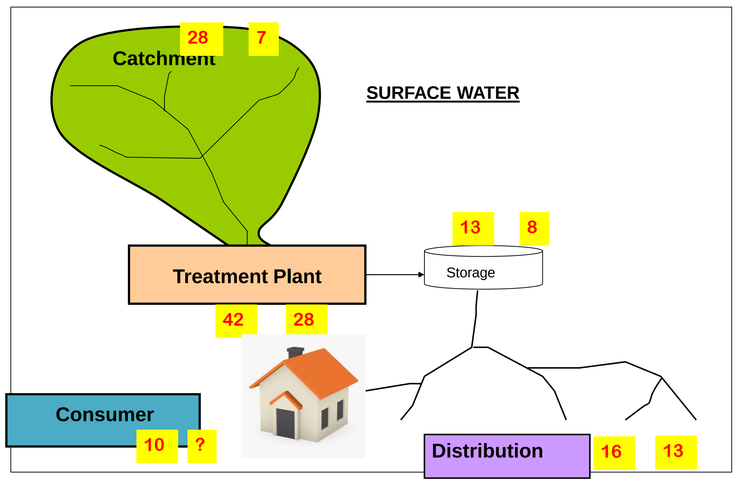
Water quality results of select localities in pilot area

Location	Source	Residual Chlorine (mg/l)	Total coliform (CFU/100 ml)	Fecal coliform (CFU/100 ml)
Pandrabaudi	Tap	1.5	0	0
	Tap	1.5	0	0
	RO filter	0	0	0
	Tap	1	0	0
	Tap	0.8	0	0
	Tap	1.75	0	0
	Stored	0	0	0
	Tap	1.5-2	0	0
Ramnagar	Tap	1.5	1	0
	Tap	1.5	0	0
	Tap	1.0	0	0
	Tap	1.0	0	0
	Tap	1.5	0	0
	Tap	1.5	0	0
	Tap	1.0	0	0
	Tap	1.0	0	0

Framework to evaluate impacts of WSP (CDC, 2011)

Inputs – what resources are available to the program	In this case, inputs include the WSP team consisting of officials from NEERI, NMC and other stakeholders as well as financial support from the World Health Organization.
Activities – what the program does with the inputs	These are the steps carried out in development of the WSP.
Outputs – direct products of the activities	In this case, the output is the WSP document itself.
Outcomes – intermediate changes	These include changes in consumer behavior, level of functioning etc.
Impacts – ultimate change as a result of the activities	These include health improvements, reduction in disease burden etc.

Reduction in hazards in pilot area



Wise Water Management System for Ashrams (Residential Schools) and Households

Raw Grey Water

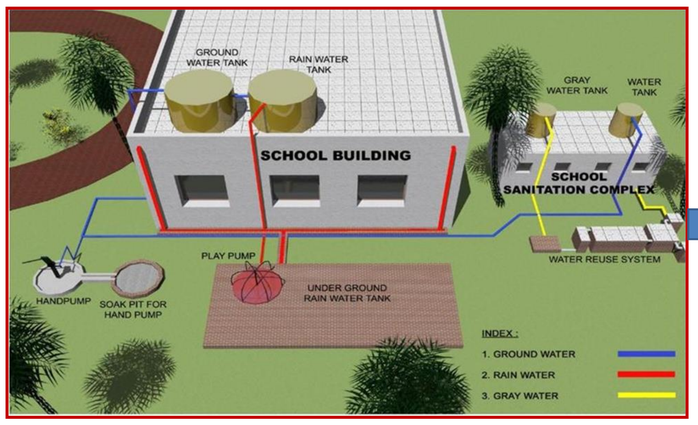
Primary Treatment
- Screening
- Sponge Filter
- Equalization tank

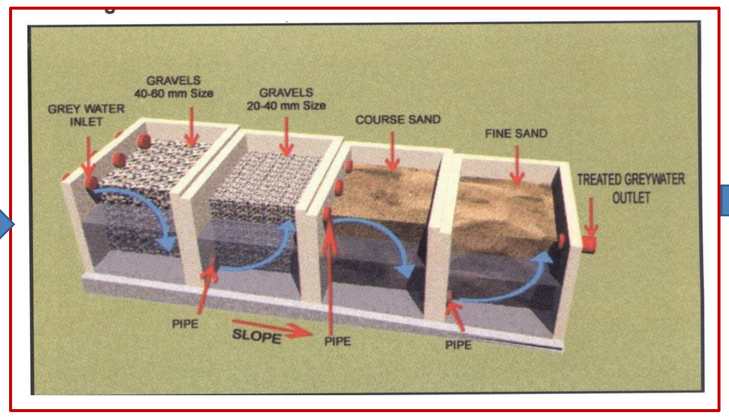
Secondary Treatment-I
- Gravel Filter
- Sand Filter

Secondary Treatment-II
- Broken brick
- Charcoal
- Chlorination

Treated Grey Water for toilet flushing, floor cleaning, car washing, gardening, irrigation, construction

Grey Water Treatment Flow Sheet





Wise Water Management Scheme

Salient Features

- Saving of 20-30 liter of water per person per day
- Cost varies from Rs. 80,000 to Rs. 150,000 to treat 5000 L/day to 20,000 L/day of greywater
- Payback period estimated to be 2 years
- Around 100 greywater treatment systems constructed in Ashram schools in Madhya Pradesh
- Around 100 greywater treatment systems constructed in households in Madhya Pradesh
- Besides removing BOD, N and P, efficient in removal/inactivation of microorganisms and helminth eggs

Novel Features

- Easy operation and maintenance
- Economical
- Provides extensive physical treatment
- Treated water is of better quality than other treatment methods
- Use of locally available filter media
- No requirement of external energy source

Design Parameters

- Water availability/scarcity
- Quantity of grey water
- Land availability
- Ground slope
- Soil type
- Reuse type such as toilet flushing, gardening, floor washing etc.
- Availability and cost of filter media