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Purification of Water

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Purification of water comes under two heading:

Purification of water on Large scale **Small scale**

- **Storage**
- **Filtration**
- **Disinfection/Chlorination**

Purification of water on **Large scale**

Storage

Results in natural purification

- ✓ **Physical:**
  - **Increase water quality**
  - **Suspended particles (90%) settles down**
  - **Allow the penetration of light and easy filtration**
- ✓ **Chemical:**

  Oxidation of organic matter by microbes
  - **Decreases free ammonium**
  - **Increases nitrates**
- ✓ **Biological:**

  Pathogenic microbes gradually die out
  - **In river water 90% decrease in bacterial counts in 5-7 days**
  - **Optimum storage period 10-14 days if longer**
  - **Aquatic plants grow causing bad smell and colour**

Filtration:

98-99% microbes removed

- **Biological or slow sand filter**
- **Mechanical or rapid sand filter**

First used in Scotland (1804)

Elements of slow sand filter

- **Supernatant water**
- **Bed of graded sand**
- **Under drainage system**
- **Filter control valves**

Biological or slow sand filter

Supernatant Water:

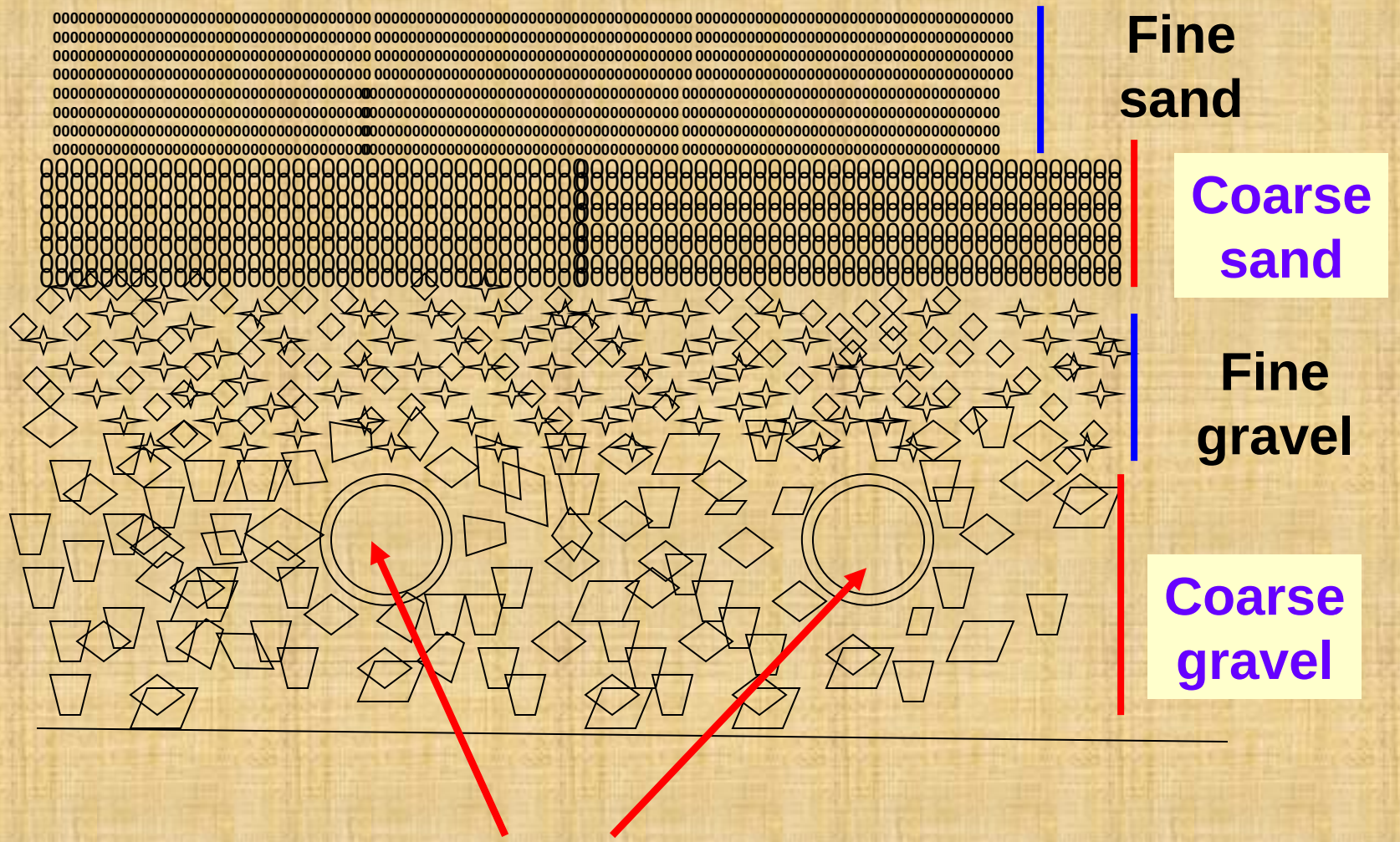
- **Depth 1.0-1.5 meter – maintained at constant level**

❖ **Purpose:**

- **Consistent HEAD of water to counter resistance**
- **Waiting period (3-12 Hrs)**
- **Partial purification**
  - ✓**Sedimentation**
  - ✓**Oxidation**
  - ✓**Particle agglomeration**

Ensures Downward flow

Section of Filter Bed



Sand bed: 1.2 meter

- Most important part of filtre
- Quality of sand
  - ✓Round with 0.15 – 0.35 cms diameter
  - ✓Clean & free form clay, organic matter
- Sand bed is supported with graded gravels
- The sand bed presents large surface area
  - 1^3 meter = 15,000 M^2
- Slow passage of water – 2 Hrs or more

- ➢Mechanical straining
- ➢Sedimentation
- ➢Adsorption
- ➢Oxidation
- ➢Bacterial action

Flow rate: 0.1 – 0.4 $m^3/h/m^2$ surface area

Vital layer:

2 – 3 cms thick when fully formed

Schmutzdecke / Zoogleal/Biological Layer

Heart of Filter

- **Slimy, gelatinous layer containing thread-like algae and other microscopic life forms**
- **Formation of Vital Layer is known as RIPENING of Biologica Filter**
- **Until formation of Vital layer, water is wasted**

- **Removes organic matter**
- **Traps bacteria**
- **Oxidizes ammoniacal nitrogen into nitrates**

Bacteria free water

Under drainage system:

- **Porous, perforated pipes for drainage of water supports**
  - ✓**Supernatant water**
  - ✓**Sand bed**

Filter Box:

- **Open rectangular Box – 2.5 to 4.0 meters deep**
- **May be below ground**

Supernatant Water	**:**	**1 – 1.5 M**
Sand bed	**:**	**1.2 M**
Gravel support	**:**	**0.30 M**
Filter bottom	**:**	**0.16 M**

Filter Control: Venturi meter

- To control the flow of water and maintain water head

Filter Cleaning:

- When the valve has to be kept fully open, cleaning is advised
- Scrap top of the vital layer to 1-2 cms depth
- After about 20 – 30 scrapings, new bed should be constructed
- When bed height is about 0.5 – 0.8 M, construct new bed

Advantages:

- **Simple to construct & operate**
- **Cheaper than Rapid Sand filters**
- **Very good quality water –**
  - **Physically**
  - **Chemically**
  - **Bacteriologically**

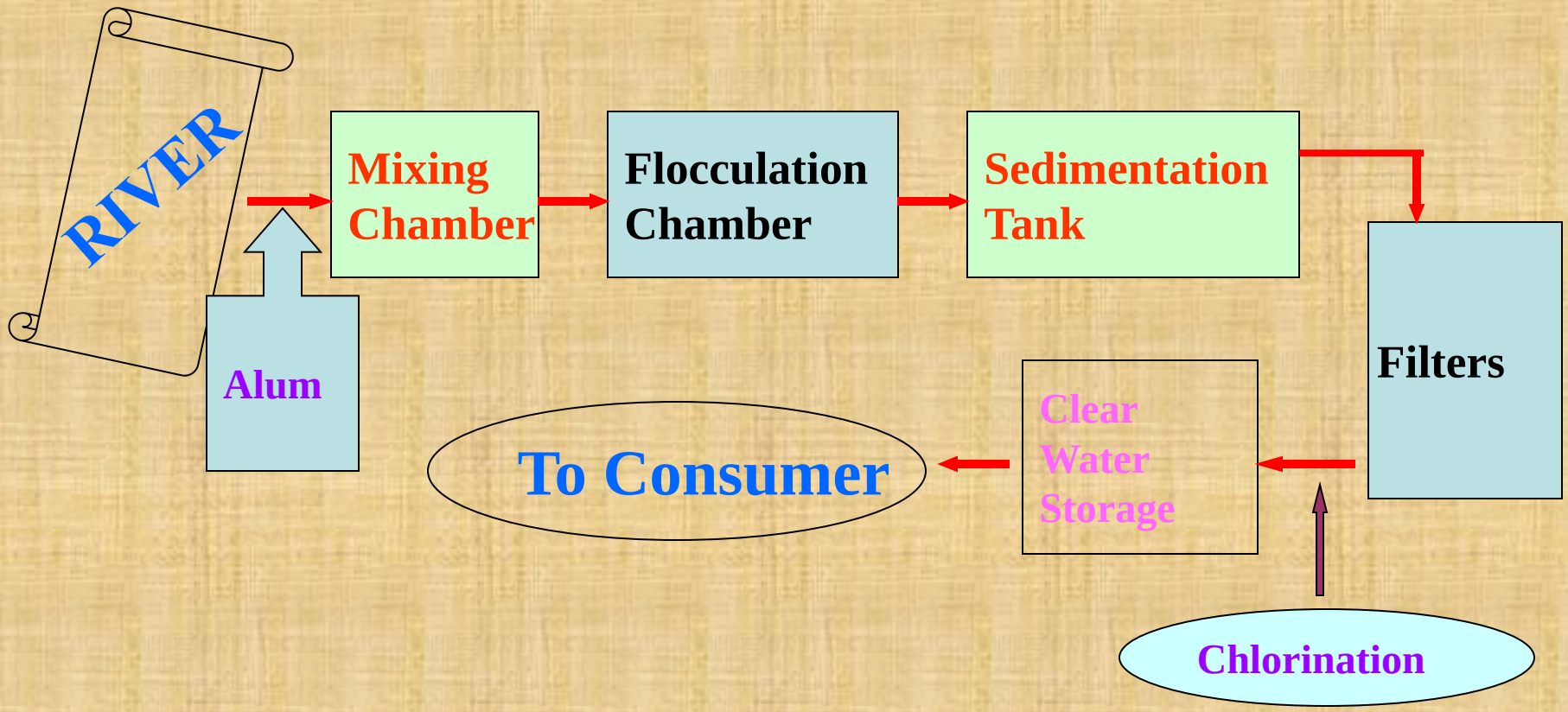
✓**Total bacterial count – 99.9 to 99.99% reduced**
✓***E. Coli* count – 99.0 to 99.9% reduction**

Rapid sand Filter
or
Mechanical Filter

1885 – First Filter in USA

Types

- Gravity
- Pressure



Coagulation:

Alum 5 – 40 mg/lit water

Depends on

- **Turbidity & Color**
- **Temperature**
- **pH**

Rapid mixing:

- **Violent mechanical mixing**
- **Rapid distribution of alum**

Flocculation:

- ✓ Slow, gentle mechanical stirring for about 30 min
- ✓ Thick floccules of aluminium hydroxide

Sedimentation:

- ✓ Stored for about 2-6 hrs for settling down of the floccules

Contains impurities & bacteria

- ✓ At least 95% of the precipitate must settle down
- ✓ Regular cleaning of the tank

Filtration:

Filter Bed:

- Surface area 80-90 m^2 (900 ft^2)
- Sand: 0.6-2 mm in size
  1 meter (2.5-3 ft) depth
- Gravel: 30-40 cm (1-1.5 ft)
- Water: 1-1.5 meter (5-6 ft)
- Filtration rate: 5-15 $m^3/m^2/hr$

When HEAD loss is 7-8 ft, the Filter is cleaned

Back Washing

Advantages

- No preliminary storage needed
- Filter beds occupy less space
- 40-50 times faster than Biological Filter
- Washing is easy
- Flexibility in operation

	Rapid sand	Slow sand
1. Space	Little	Large
2. Filtration rate	5-15 $m^3/m^2/hr$	0.1-0.4$m^3/m^2//hr$
3. Sand size	0.6-2 mm	0.15-0.35 mm
4. Prelim treatment	Chemical coagulation	Sedimentation
5. Washing	Back washing	Scrapping
6. Operation	Highly skilled	Less skilled
7. Turbidity	Good	Good
8. Colour	Good	Fair
9. Removal of Bacteria	98-99%	99.9-99.99%

Disinfection/Chlorination

Supplement and not substitute of filtration

- **Kills pathogenic bacteria**
- **No effect on certain viruses:**
  - ✓ **Polio, Hepatitis**
  - ✓ **Spores need higher dose**

✓ **Along with germicidal effect it oxidizes Fe, Mn, H_2S**

✓ **Eliminates some taste/odour producing substances**

✓ **Controls algae and slime organisms**

✓ **Aids coagulation**

Action:

$H_2O + Cl_2 \rightarrow$ **HOCl** + HCl

⇓

Neutralized with water alkalinity

HOCl $\rightarrow$ H + OCl

- **Disinfectant action is because of HOCl and OCl**
- **HOCl 70-80 times more active than OCl**
- **Best action at pH 7.0 → HOCl predominates**
- **Action of Cl_2 at pH 8.5 is unreliable**

⇓

90% HOCl → OCl

pH of water

6.0-7.5

Principle:

- **Water should be clear, free from turbidity**
- **Chlorine demand should be estimated**
- **Contact period → 60 min**
- **Minimum concentration of free Cl_2:**
  0.5 mg/lit for one hour
- **Correct dose:**
  Cl_2 demand + Free Cl_2

Chlorine demand:

- Difference between amount of Cl_2 added and amount of residual Cl_2 at the end of specific period of contact (60 min) at a given temperature and pH of water

Break Point:

- Amount of Cl_2 needed to destroy bacteria and oxidize organic matter and ammonical substances present in water

The point at which free chlorine starts appearing in water

The point at which Chlorine Demand of water is met

Method of Chlorination

Chlorine gas:

First choice, replaced other Cl_2 derivatives

- **Cheap**
- **Quick in action**
- **Efficient**
- **Easy to apply**

Use chlorinating equipment

Irritant

Chloramine:

- ✓ **Loose compound of Cl_2 and NH_3**
- ✓ **Decrease tendency to give chlorinous taste**
- ✓ **Increase persistent residual Cl_2**
- ✓ **Slower action as compare to Cl_2 gas**

Perchloron:

- Ca-compound with 60-70% of Cl_2

Break point chlorination/Free residual chlorination - Only reliable method of chlorination

Addition of Cl_2 till all organic matter present in water is completely oxidized and a little amount of free chlorine is left in water

Superchlorination:

- It is followed by dechlorination

- Used in heavily polluted water

Orthotolidine test

- **Developed in 1918**
- **Detects both free & Combined chlorine**

O-tolidine (AR) solution in HCl (10%)

Yellow color – proportional to concentration

- **Reacts instantaneously with free chlorine**
- **Reacts slowly with bound chlorine**
  - ✓ **0.1 ml OT reagent + 1.0 ml Water**
  - ✓ **Take reading within 10 seconds**
  - ✓ **Color appearing after 15-20 min – due to bound Cl_2**

Orthotolidine-Arsenate (OTA) test

- **Modification to eliminate reactions on account of interfering substances such as iron, manganese etc**

Ozonization: **Great potential usefulness**

1906 → France → First ozone treatment plant

Advantages

- Powerful oxidizing agent
- Removes undesirable odour, colour and taste
- Inactivates viruses

Disadvantages

- No residual effect
- Destroys chlo-organic compounds
- 0.2 to 1.5 mg/lit water

UV-irradiation:

- **Effective against most water containing microbes, not used on large scale**

  - **120 mm thick water table**
  - **200-295 nm wavelength**

Advantages

- **No residual taste, odour**
- **Very short exposure**
- **Over-exposure has no side effect**
- **No foreign substance introduced**

Disadvantages

- **Very expensive**
- **No residual activity**
- **Color/turbidity in water effectiveness**
- **No rapid test to detect effectiveness**

Small-scale purification

House:

Boiling:

- ✓ **Rolling boil (5-10’)**
- ✓ **Taste altered**
- ✓ **No residual effect**

Chemical disinfection:

Bleaching powder:

- ➢ **Chlorinated lime**
- ➢ **CaOCl2 –unstable, 33% available Cl2**
- ➢ **Mixed with lime 0.5 mg/lit**

Chlorine tablets:

- Costly, good for small scale use
- 1 tab (0.5 gm) → 20 lit water

Iodine:

2% solution → 2 drops/lit → 20-30’

- High cost
- Physiological activity

Chlorine solution:

4 kg Bleaching Powder (5% solution of Cl_2)

⇓

20 lit Water (25% Cl_2)

Water filters:

- Chamberland filters
- Berkfeld filters

Disinfection of wells

1. Volume of water (lit.)
2. Amount of bleaching powder

Volume : $\frac{3.14 \times d^2 \times h}{4} \times 1000$

d: Diameter in meter
h: Depth of water table in meter

Bleaching powder :

2.5 g/1000 lits water (0.7 mg Cl_2/lit of H_2O)

Dissolve in water and discard sediment

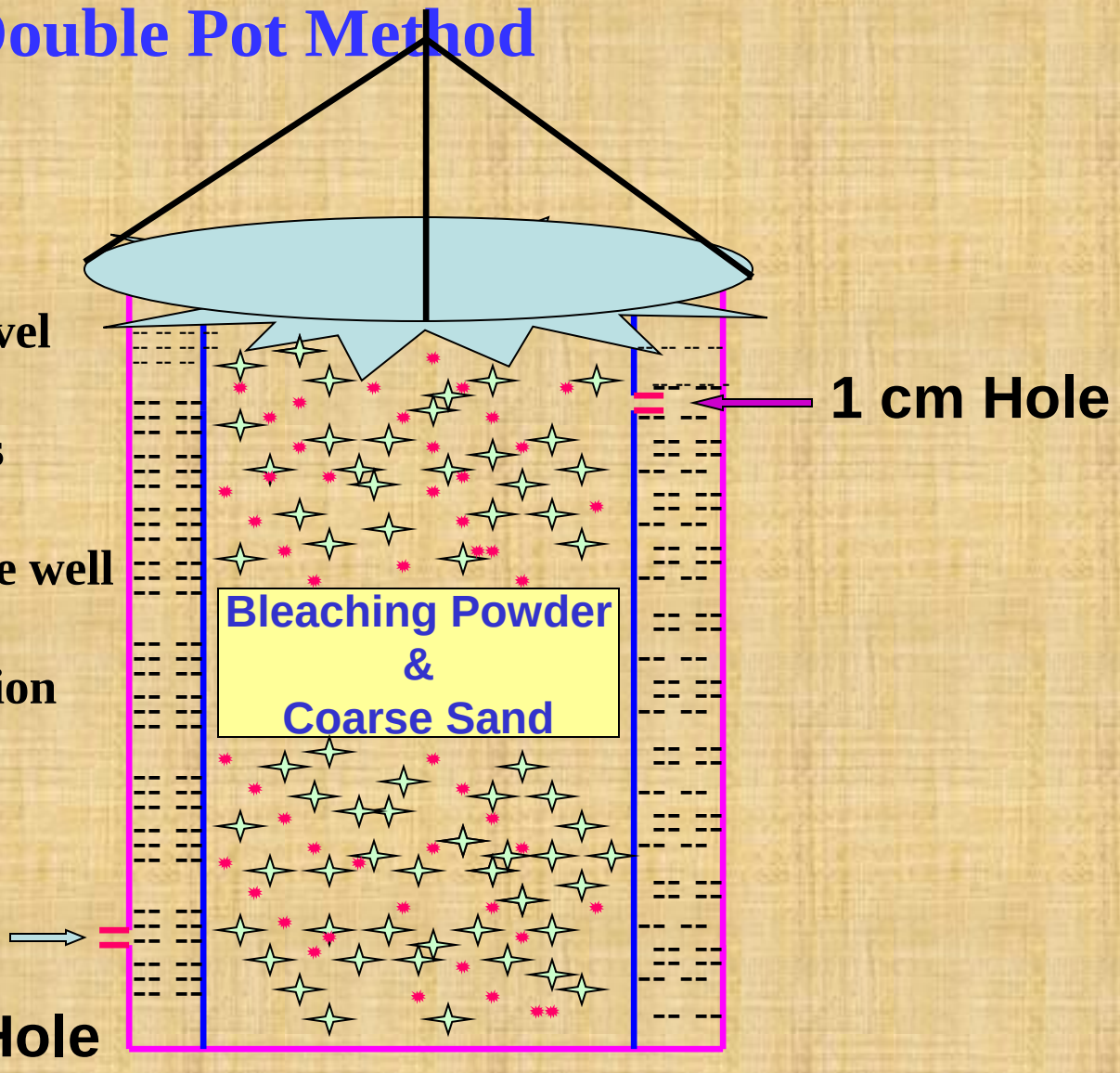
Discard Lime → Hardness

- Add this solution to water in well
- Leave for 1 hour, Test by OTA

Double Pot Method

- Continuous release of Cl_2
- One meter below water level

- Satisfactory for 2-3 weeks
- with 4,500 lits water in the well
- 360-450 lit/day consumption



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