CHALLENGES & MEASURES IN TUBEWELL BASED GROUND WATER EXTRACTION

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ABSTRACT

The basic element for sustainable life on the earth is water, which contributes in happiness, energy, health, piety, prosperity to each and every creature of our Universe.

Water is one of the most important requirements of life. Assured availability of potable water is vital for human development. India is home to 18% of global human population and 15% of global livestock population. However, it has only 2% land mass and 4% of global freshwater resources.

As per estimates; in 1951, per capita annual freshwater availability was 5,177 cubic meters which came down to 1,545 cubic meters in 2011. It is estimated that in 2019, it is about 1,368 cubic meters which is likely to further go down to 1,293 cubic meters in 2025. If present trend continues, in 2050, freshwater availability is likely to decline to 1,140 cubic meters.

With the growing population and expanding economic activities, there is an increase in demand for water in various sectors, viz. agriculture, industry, domestic, recreation, infrastructure development, etc., whereas the source of water is finite. Thus, finite availability and competing demands make drinking water management a complex issue. The widening demand-supply gap is further compounded by other challenges, viz. depletion of groundwater caused by over-extraction, poor recharge, low storage capacity, erratic rainfall due to climate change, presence of contaminants, poor Operation and Maintenance (O&M) of water supply systems, etc. In pre-Independent India, the water management systems and structures were adequate to cater to the low population. Local communities have been known for designing their own systems using traditional knowledge and wisdom to fulfill needs of the community in different climatic conditions. However, with increasing population and disruption in rainfall pattern and decrease in storage, challenges related to scarcity of water have become acute.

INTRODUCTION

In order to meet the water demand, a suitable source of water is required to be identified. This source should satisfy the requirement in terms of quantity as well as quality. The usual sources of supply of water are rivers, canals, lakes, ponds, and wells etc. and may be classified as followings;

a) **Surface Water -** Surface water is water in river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapo-transpiration and sub-surface seepage.

b) **Under River Flow** - Throughout the course of the river, the total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through sub-surface rocks and gravels that underlie the river and its floodplain called the hyporheic zone. The hyporheic zone often forms a dynamic interface between surface water and ground water, receiving water from the ground water when aquifers are fully charged and contributing water to ground water when ground waters are depleted.

c) **Ground Water -** Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table.

d) **Desalination** - Desalination is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most alternative sources of water.

Most common source of water supply is underground water. The underground water is generally extracted through tubewells which is also sometimes called as Borewells.

CLASSIFICATION OF TUBEWELLS

Based on the depth of water level and size, Tubewells were classified as followings;

A. **Shallow Tubewells:** These are Borewells less than 30 m deep having casing diameter less than 6 inches.

B. **Deep Tubewells:** A deep borewell shall be defined as a borewell of depth more than 30m below the ground surface, having casing diameter of 6 inches or more.

These Deep Tubewells / Borewells are further classified according to yield as under:

a) **High Capacity Tubewells:** are classified as per following specifications;

- Casing Pipe Diameter - 10 or 12 inches
- Depth - >80 m with
- Design Yield Range - 1500 LPM to 3500 LPM) approx.

b) **Medium Capacity Tubewells:** are classified as per following specifications;

Casing Pipe Diameter - 8 inches

- Depth - >80 m with
- Design Yield Range - 750 LPM to 1500 LPM) approx.

c) **Low Capacity Tubewells:** are classified as per following specifications;

- Casing Pipe Diameter - 6 inches
- Depth - 30 m to 50 m
- Design Yield Range – 100 LPM to 750 LPM) approx.

GUIDELINES

The guidelines related to tubewells are contained in following IS Codes and these IS Codes (with their latest revisions) are required to be followed for specifications -

1. Construction and Testing of Tubewells - **IS 2800**
2. Gravel for use as pack in Tubewells - **IS 4097**
3. Steel Tubes used for Tubewells - **IS 4270**
4. Well Screens and Slotted Pipes - **IS 8110**
5. Development of Tubewells - **IS 11189**
6. Accessories for Tubewell Assembly - **IS 226**

CHALLENGES

The common challenges / shortcomings observed in design, construction and management practices in borewells are as under:

(i) The design and selection of size of opening and length of the screen, and the size and grading of filter media are of utmost importance as these aspects affects quantity and quality of water and service life of borewell. Coarser formations in aquifers require larger grain size of filter media and larger opening of the screen, and the finer formations require smaller size of filter media and smaller openings in the screen. Design of the screen and the filter media should be decided on the basis of the grain size distribution of the formation in the aquifer at the intake zone and not on the general grading of the formation. Decision on the selection of screen and filter media should not be left to contractor or someone's general experience.

(ii) The screen portion is many time kept too long in most of the borewells and covers almost 1/3rd to 2/3rd of the depth of the borewell. It is advisable to always keep the screen in the deepest part of the borewell. Screen extending so high in the borewell is likely to affect development of graded zone, and also increase proneness to contamination because water from the higher levels will tend to flow into the well through the annular space filled with gravel.

(iii) If the thickness of filter pack is too large (> 200mm), then it hinders the development of the graded zone. Filter pack thickness of 200mm is the upper limit permissible under IS code and should be adopted for very deep wells (>150m deep) of large diameter. There is also inadequate control in lowering of the casing pipe and screen into the borehole with the result that the screen may not be properly aligned along the axis of the bore resulting in failure to achieve uniform thickness of the filter pack all around the screen which is essential for proper development of the well and good yield.

(iv) Even borewells in coarse grained strata, like sandy gravels, where there is no need of providing a filter pack and the borewell can be developed naturally, full filter packs are being provided. This is unnecessary expenditure and also adversely affects development of the well.

(v) Normally, slotted casing pipes are being used as screen. These screens have small open area and result in very long screens. Wire wound continuous screens provide large slot area without loss of strength of the pipe and are now commonly used for high yielding deep borewells.

(vi) In case of corrosive aquifer conditions, such as, high content of chlorides, TDS, Hydrogen sulfide etc. MS casing pipes and screens should not be used as they are prone to corrosion.

(vii) The existing practice of classification of formation strata is faulty. Terms like "fine-sand", "coarse sand", "fine silt", "very fine clay" is being used when in nature, such soils rarely exist. This flawed classification impairs appreciation of strata-charts of existing wells.

(viii) Well completion reports should be prepared properly, highlighting and documenting the essential features of the borewell. Similarly, strata samples should not be destroyed after the installation of a borewell.

(ix) There should be a system of passing of important materials like casing pipes, screens, pea-gravel to be used in the construction of borewells as it is a completely hidden work and it is impossible to check the quality of the material after the borewell has been constructed.

(x) In the alluvium aquifer of North India, borewells of depth 30 to 50 m give good potable water and a deeper borewell is required only from quality considerations at those specific locations where the water at shallow depths is having high TDS or harmful substances like arsenic.

Deep borewells of 80 to 150m or more are basically provided for obtaining a higher yield, though undoubtedly quality also improves. The reduced yield in most cases is because of clogging of the screen and filter media. Running a deep borewell at a fraction of its original capacity is uneconomical because of high energy consumption, yet many borewells whose yield has gone down to 1/3rd to 1/5th or more of the original yield are being used.

(xi) A borewell should be commissioned immediately after its installation. However the practice of providing the pump house right above the borewell delays the commissioning and pumping test by several months. Room for electrical control panel and chlorination plant may be constructed a short distance (5 to 20m) away from borewell to avoid the delay in commissioning of borewell.

(xii) There is also scope of improvements in other aspects like;

- Proper development of the aquifer after installation of casing pipe and screen.
- Proper estimation of yield and pump capacity by drawing drawdown and recovery curves from pumping tests.
- Proper bacteriological and chemical analysis of water.
- Disinfection of the borewell by shock chlorination before commencing supply, if required.

BEST PRACTICES

A tube well is not completely ready for use just after construction. The next important step is to develop the drilled tube well. The tube well can function successfully only after proper development. It is the process by which the finer particles from around the screen are removed to increase the permeability of the formation through which water moves towards the well.

METHODS OF DEVELOPMENT

When the water bearing strata in which well is drilled is made up of sand and gravel or alluvium, development it accomplished by removing finer particles from the area surrounding the tube well.

The following are the methods commonly adopted for development of a tube well:

1. Development by pumping
2. Development by compressed air
3. Development by surging
4. Development by back-washing
5. Development by high velocity jetting
6. Development by using chemicals.

1. Development by Pumping:

It is the simplest and most common method of removing fine particles. In this method water is ultimately pumped from the well at a rate equal to or higher than the design discharge. So it is a case of over-pumping. A variable speed pump of large capacity is used. Water is withdrawn at a very slow rate in the beginning. Then the rate of withdrawal is increased in steps. In between the steps the rate of withdrawal is kept constant until no further sand particles are removed.

Pumping should be continued until the maximum discharge is reached and no further sand particles are withdrawn. The water withdrawal is then stopped and the water level is allowed to rise to its normal position. The procedure is again repeated until no further sand particles are removed. In the initial stages of pumping if the speed is maintained high fine particles get sucked in with great force and may clog the perforations in the pipe or the filter media. It may cause failure of tube well.

The limitations of this method are the following:

i. It induces velocity in radial direction only and therefore the fine particles are removed in one direction only. It is partly overcome by intermittent pumping which agitates water in the well.

ii. It removes fine particles from limited area surrounding the screen.

iii. It requires pumps of larger capacity than conventionally available.

Owing to above limitations this method is not found very effective for developing large capacity wells. For small wells, however, it is quite suitable and commonly used.

2. Development by Compressed Air:

The main components of this assembly are a air pipe (air line) of smaller diameter and a drop pipe of bigger diameter. The drop pipe is also called discharge pipe because the assembly is similar that of air lift pump assembly. An air compressor is directly connected to an air tank which in turn is connected to the air pipe through a quick opening valve.

In this method an assembly of air pipe of smaller diameter and drop or discharge pipe surrounding the air pipe is introduced into the well till it reaches nearly bottom of the first strainer pipe. The air pipe is so adjusted that its bottom end is about 30 cm above the lower end of discharge pipe. It is called pumping position of the air pipe.

The air is then compressed into the well to start pumping. The pumping is continued till the pumped water is free from sand. At this point air entry is cutoff by closing the valve. The tank is brought to full pressure by keeping the compressor on. In the mean time the air pipe is so lowered that now it emerges below the lower end of discharge pipe by 30 cm.

It can be called back-washing position of the air pipe. Now the valve is quickly opened to allow sudden rushing entry of compressed air into the well. Because of heavy rush of air a surge of water is created. It forces the well water into the aquifer through the screen. The surge agitates the aquifer and dislodges the fine sand particles.

The air pipe is again raised inside the discharge pipe, i.e., to a pumping position and as the pumping starts the direction of flow is reversed and now water enters the well through the soil. The entering water brings with it dislodged fine sand particles. The process of alternate airlift pumping and surging is continued till the aquifer is fully developed and sand flow is stopped. In this manner full aquifer is developed taking 1 to 2 m length of the screen at a time.

3. Development by Surging:

A surge is formed by the reciprocating movement of a plunger in the well. The water moves alternately into the soil and comes out in the well during downward and backward stroke respectively. The speed of the plunger is slowly increased. The plunger is operated in the casing pipe provided above the screened portion of the well. The repeated application of surging force draws the fine particles into the well, leaving coarser particles intact in the aquifer.

Sometimes to increase efficiency of development a dispersing agent like calgon (sodium hexa-meta-phosphate) is added to well water. Alternate surging and bailing is continued to draw sand from aquifer and to remove that water from the well respectively till no sand is drawn into the well.

4. Development by Back-Washing:

As the name suggests it is a process in which the water is made to flow into the aquifer formation from the well through the screen. The back-washing causes agitation of the formation and breaks down the bridging of sand particles. Back-washing thus helps in effective removal of fine particles. Various methods can be used for creating back-wash or causing reverse flow.

Main methods are the following:

(a) Intermittent pumping method:

When pumping is started and stopped intermittently it produces rapid changes in the pressure head in the well. When the pumping is stopped suddenly the water column in the well falls down causing reverse flow. The process is repeated till development is done which can be ascertained by sand pumping.

(c) Back-washing with bailer:

In this method water is fed into the well as fast as possible and then it is bailed out with sand pump or bailer. The movement of water agitates the formation around the well. Faster rates of feeding and bailing ensure effective agitation and vigorous suction of fine material respectively. Bailed water can be reused after allowing the sand to settle down in a settling tank.

(c) Back-washing with air pressure:

The principle adopted is similar to one adopted for compressed air development method with some modification. In this method in addition to air pipe and discharge pipe assembly there is one more small air pipe. The air pipe and discharge pipe assembly serves the purpose of air lift pump whereas the small air pipe compresses the air into the sealed well to create reverse flow. In this method the well is sealed at top after inserting the assembly of air and discharge pipes and another small air pipe. The compressed air is fed to both the pipes through a three-way valve.

The air lift pump assembly functions as usual to pump out the water. When clear water comes out of the well pumping is stopped by cutting air supply. When the water level regains static level air supply is diverted through smaller single air pipe.

Compressed air admitted into the well causes reverse flow through the screen into the formation. The back-wash agitates and dislodges the sand particles in the formation. When water level in the well goes below and air starts escaping through discharge pipe the air valve is turned to activate air lift pump assembly.

The pumping starts and sand and water is pumped out. The process is repeated till the well is developed thoroughly. Sometimes dispersing agent is used to accelerate the process. It may be seen that although back-washing is essential it alone cannot effectively develop the well unless it is combined with surging, bailing or pumping.

5. Development by High Velocity Jetting:

It is one of the most effective methods of development. In this method high velocity jets released through the jetting tool pass through the screen and the formation behind the screen gets agitated. It loosens the fine particles which can be removed from the well by pumping or bailing the well water. Figure 18.10 makes the procedure clear.

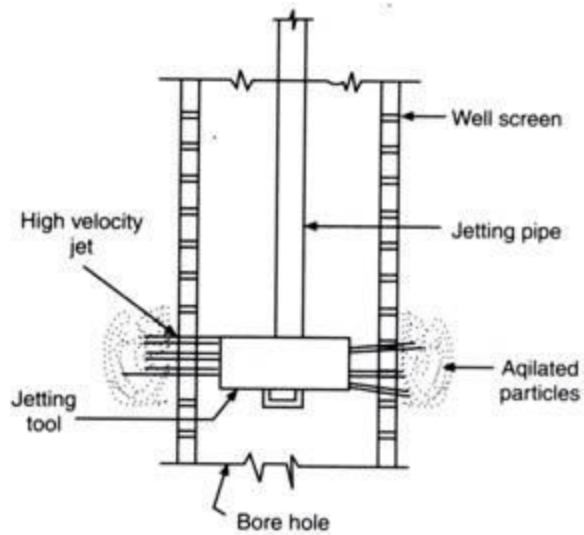

Fig. 18.10. High velocity jetting method

This method has following advantages:

i. The energy is concentrated over a small area and is therefore more effective.

ii. Each portion of the screen can be covered selectively and completely.

iii. The process is simple and does not require elaborate arrangement or special equipment.

iv. There is little chance of over development by this method.

6. Development by Using Chemicals:

Dispersing agents are many times added to the water used for back-washing or jetting. The dispersing agents counteract the property of clay to stick to sand particles. The common dispersing agents which are quite effective are various polyphosphates like Tetrasodium pyrophosphate. Sodium tripolyphosphate, sodium hexametaphosphate (calgon) and sodium deptaphosphate. Once the dispersing agent neutralises colloidal property of clay it can be easily removed by surging and back-washing.

Lately two chemicals, namely, hydrochloric acid and solid carbon dioxide (also called dry ice) are used for development of wells. In the well to be developed hydrochloric acid is added and the well is sealed at top. A back-wash is created by forcing compressed air m the well.

As a result hydrochloric acid mixed water enters formation around the screen. The top seal is now removed and dry ice or solid carbon dioxide is dropped into the well. The sublimation takes place and in the process carbon dioxide is released. As a result high pressure is built up in the well. When the pressure is released muddy water is forced up and is thrown out of the well in the form of a jet. Thus the development to well is accomplished.

This method is also used for removing incrustation and corrosion of the well screens. When a well is drilled in a sedimentary rock formation development is done by dissolving the cementing material partly. Thus bigger cavities and openings are formed around the well. When a tube well penetrates rocky formation the development is done by fracturing the surrounding rock formation to create additional openings. Then more water enters the well through the fractured rock formation.

CONCLUSION

Proper Construction & Development of Tubewells serves following functions:

i. It clears the water bearing formation clogged by the mud in the drilling operation.

ii. It causes the gravel pack and surrounding formation to settle and to get compacted against the screen, thus it makes the tube well structure stable.

iii. It serves to breakdown the bridging of sand grains across the screen openings and in the surrounding gravel pack and aquifer formation and makes the well efficient.

iv. It helps in obtaining sand free water by stabilising the sand formation around the screen.

v. It helps in reducing head losses near the screen.

vi. It brings the well to its maximum capacity that is maximum yield is available at minimum drawdown.

vii. It gives a measure of available water supply and helps in determining the required characteristics of a pump and power unit to be installed.

viii. It increases useful life of the screen or strainer.

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