STATUS OF GROUND WATER IN BHUBANESWAR CITY, ODISHA

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Abstract

Bhubaneswar, the capital of Odisha is known as “Temple City of India”. The city was adopted as the Capital city of Odisha in 1948. Subsequently a number of offices, organizations and other infrastructural facilities developed in the city to keep pace with time. As of now, Bhubaneswar is under tremendous pressure because of the rapid urbanization and tourist importance. The present Bhubaneswar is transforming towards a new identity apart from its cultural heritage, as a major centre for information technology, educational and research organization and attracting millions of tourists both from India and abroad. The city experiences a humid sub-tropical climate. The rainy season is from June to September. The winter extends from December to February. And summer season is from March to May. The average annual rainfall is around 1380 mm (1996 to 2009) and about 80 % of annual rainfall is received from the South-West monsoon from June to September. Ground water development is through open / dug wells, shallow and deep bore wells as well as shallow & Filter point tube wells. PHED, Govt of Odisha is the major organization for withdrawal of ground water for domestic water supply. Besides this, the dwelling complexes like flats and individual house owners also use ground water where PHED pipe water supply is not available. The top weathered zone overlying the gritty and partially lateritized Athagarh sandstones of Gondwana are mainly tapped by dug wells & filter point tube wells. In general it has been found that the ground water from both the shallow and deeper zones are slightly acidic in nature. The ground water quality of the Bhubaneswar city has been studied by analysing water from dug wells and bore wells. In general it has been found that the ground water from both the shallow and deeper zones are slightly acidic in nature. The deeper aquifer though in general contain a little higher concentration of iron than that of permissible limit but the dug well water normally does not show any higher concentration beyond permissible limit except in isolated cases as the dug well water remains in constant contact of atmospheric air which facilitates oxidation and precipitation of iron. The analysis data also indicated that concentration of different chemical constituent and pH vary in pre and post monsoon period.

Keywords: Ground water development, open / dug wells, shallow and deep bore wells as well as shallow & Filter point tube wells, pH

1. INTRODUCTION

Bhubaneswar, the capital of Odisha is known as “Temple City of India”. The city has rich cultural background and represents some of the finest manifestations of Kalingan style of temple architecture. Bhubaneswar at present stands at the confluence of the past and the present and proudly manifests the soaring spire of Lord Lingraj, the Raja Rani temple, the Pagoda of Dhauli, popularly known as the white dome of peace, the Jain temples and the caves of Khandagiri and Udaigiri. Bhubaneswar, once a flourishing capital of ancient Kalinga, is today the largest city in Odisha. The city has a long history and it dates back to the period of great Mauryan emperor Ashoka. During the days of Mauryan Emperor, it was known as “Tosali”, the Capital City of Ancient Kalinga. The serene land has such inherent mysterious power that it could turn the great Mauryan Emperor Ashoka to the compassionate teachings of Lord Budha after horrendous Kalinga war in the 261 B.C. Today, because of its magnificent culture and heritage, Bhubaneswar is an important tourist centre not only in India, but also in the whole world. Tourism is the major industry of the city. The Lingaraj Temple, Mukteswar temple and Raja Rani Temple(1000 AD), Ashok inscriptions at Dhauli, archaeological remains of Sisupalgada (300 B.C.) and Jain monuments of Khandagiri and Udaygiri (between 200 B.C. to 100 A.D.) are some of the important monuments of the city. The old city, popularly known as, Ekamrakhsetra, featured by conglomeration of temples, monuments, mandapas, heritage ponds etc. The city was adopted as the Capital city of Odisha in 1948. Subsequently a number of offices, organizations and other infrastructural facilities developed in the city to keep pace with time. As of now, Bhubaneswar is under tremendous pressure because of the rapid urbanization and tourist importance. The present Bhubaneswar is transforming towards a new identity apart from its cultural heritage, as a major centre for information technology, educational and research organization and attracting millions of tourists both from India and abroad.

2. GENERAL FEATURES

2.1 Demography : The extent of infrastructure requirements and urban services mainly depend on size of the population residing in the city. The city has grown from a meager population of 8170 in 1921 to 6,57,477 in the year 2001, which is highest in the state.. There has been steady growth of population in Bhubaneswar city except for the first two decades when there was a drop in the population. This was mainly due to epidemics like cholera, plague etc. There has been sudden rise since 1941. The sudden rise in population was due to the migration of the people from all over Odisha to Bhubaneswar. The city experienced the highest growth rate in 1961-1971. This was the highest growth (176.07%) rate experienced by any other capital cities in the country. This was due to expansion of the administrative, liaison, and institutional and industrial activities.Later on the city experiencing a fall in the population growth rate. The reduced population growth during 1981 to 1991 could be the restricted industrial development due to the declaration of the Bhubaneswar Urban Area as the 'Air Pollution Control Area'. The increase in population from 1991 to 2001 at the normal rate is the normal urbanization trend as is happening in other cities of the country[1]. The Projected Population for 2011 is likely to be around 13,14,954. The average tourist inflow to the city is around 3500 per day.

2.2 Hydrometeorology : The city experiences a humid sub-tropical climate. The rainy season is from June to September. The winter extends from December to February. And summer season is from March to May. The average annual rainfall is around 1380 mm (1996 to 2009) and about 80 % of annual rainfall is received from the South-West monsoon from June to September. The analysis of long term rainfall data indicates that on an average the city experiences mild drought in 30% cases and 8% normal drought and no severe drought. May is the hottest month with the mean daily temperature of 38 °C while December is the coldest month with mean daily temperature around 16 °C. The mercury rises upto 48 °C during summer while it drops to 9.4 °C during the winter. The relative humidity varies from 48 to 85% and sometimes goes upto 95%. Wind speed is fairly strong during summer and monsoon months and major directions from SW and South. The average wind speed is around 14 Km/ Hour. The mean monthly potential evapo-transpiration varies from 57 mm in January to 248 mm in May.

2.3 Physiography & Drainage : Bhubaneswar city area is characterized by undulating upland topography in western and central part while eastern part shows more or less flat topography with gentle slope towards east or south east. Altitude varies from 60m in the western part to 15m in the extreme eastern part. The East Coast Railway line forms the broad boundary between the above mentioned morphological setups. The upland areas shows lateritic cover while gently sloping area shows mainly alluvial cover with or without thin lateritic cover on the top. The upland areas in the western part are dotted with isolated hillocks made up of shale-sandstone sequence of Upper Gondwana rocks belonging to the Athgarh Formation. The main drainage channel is the Kuakhai River which is a distributary of the Mahanadi River. The Kuakhai River flows more or less along the eastern margin of the city. The Kuakhai River has been subdivided into Bhargavi and Daya River in the extreme south eastern part of the city. The Daya River flows in more or less along the south eastern margin of the city. Besides these, a number of small streams originates from the western upland areas and flows through the city mostly in easterly and south easterly direction and falls either in Kuakhai or Daya River[2]. The Kuakhai and Daya rivers are perennial while the other minor streams are ephemeral in nature. The hydrogeomorphological map of the Bhubaneswar city is shown in figure 1.

2.4 Pedology : The soils of the city can be divided into Alfisols and Ultisols

Alfisols : The texture of this soil is sandy loam and these occur in the eastern part of the city. The soils are generally deficient in phosphorous and nitrogen and pH ranges from 6.5 to 7.3.

Ultisols : The laterite and lateritic soils cover rest of the city area. These soils are characterized by a compact to vermicular mass in sub-soil horizons, composed merely of mixture of hydrated oxides of Aluminium and Iron and are devoid of the alkali and alkaline earth metals

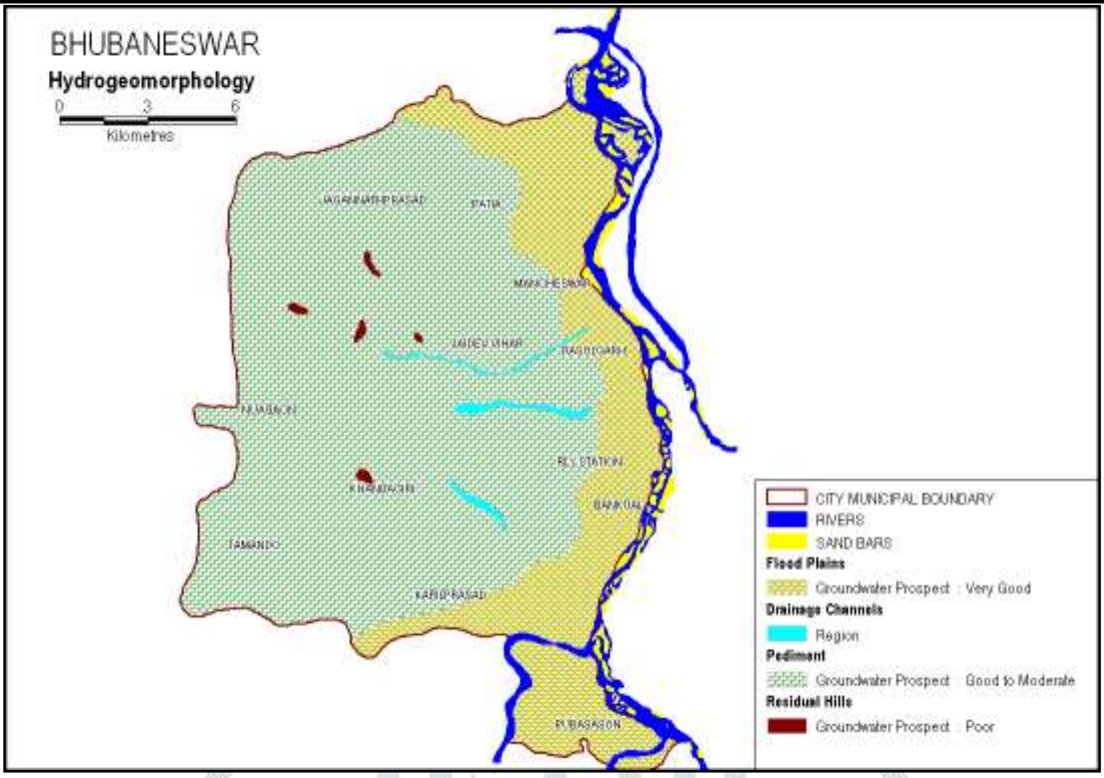

Figure 1 : Hydrogeomorphological Map of Bhubaneswar City

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3. STATUS OF WATER SUPPLY & DEMAND

The PHED at present (March' 2010) supplies 206 MLD of water through pipe water supply scheme and out of which the supply from ground water source is 41.6 MLD and the rest is from the surface water source. PHED generally withdraws 41.6 MLD i.e., 4.16 HaM / Day of ground water through 103 deep bore wells for pipe water supply. Besides this, the dwelling complexes like flats and individual house owners also use ground water where PHED pipe water supply is not available. It has been estimated that 20 MLD ground water is drawn through shallow / deep bore wells and open / dug wells which accounts for 2HaM per day. The estimated water requirement for the city by the year 2020 is about 422 MLD at the rate of 165 litres per person per day. Apart from this, there may be additional requirement of water for smooth functioning of city life. The available ground water resource in the city master plan area indicates that ground water can supply 122 MLD maximum considering 85% utilization of the available annual replenishable ground water resources of 5242.5 HaM. The balance requirement which amounts to more that 300 MLD is to be met from other resources like surface water sources etc. However, ground water draft of 162 MLD may be feasible considering the fact that the draft during rainy season does not affect the annual replenishable resource and available resource can be utilized for non-rainy seasons. Under this situation also the balance requirement of 260 MLD of water is required to be arranged from other sources. The water supply system of Bhubaneswar.

4. WATER PROFILE

4.1 Surface Water : Bhubaneswar City gets its water supply from Mahanadi, Kuakhai and Daya River. River Daya and River Kuakhai is needed for drinking water supplies for the current and the future needs of the City and for carrying storm water and the treated Sewage from the City. Presently, water supplied to the City is about 182 MLD. In addition, the city is part of canal command area of Puri Main Canal. A few of the distributaries, minor & sub-minors of this canal passes through the eastern fringe of the city, where it is extensively utilized for agricultural purposes. There are some minor cold water springs in the western upland areas. The springs are mostly seasonal and discharges of water in these springs are either that water trickles down or oozes out. Discharge begins during rainy season and last maximum upto December / January month. The discharges are very low – negligible to a maximum of 20 lpm during rainy season and the discharge also gradually decreases after the cessation of rainy season[3].

4.2 Ground Water : Ground water development is through open / dug wells, shallow and deep bore wells as well as shallow & Filter point tube wells. PHED, Govt of Odisha is the major organization for withdrawal of ground water for domestic water supply. Besides this, the dwelling complexes like flats and individual house owners also use ground water where PHED pipe water supply is not available. The top weathered zone overlying the gritty and partially lateritized Athagarh sandstones of Gondwana are mainly tapped by dug wells & filter point tube wells. In general it has been found that the ground water from both the shallow and deeper zones are slightly acidic in nature. The deeper aquifer though in general contain a little higher concentration of iron than that of permissible limit but the dug well water normally does not show any higher concentration beyond permissible limit except in isolated cases as the dug well water remains in constant contact of atmospheric air which facilitates oxidation and precipitation of iron.

5. GROUND WATER SCENARIO

5.1 Potential Aquifer : Bhubaneswar city is underlain by geological formations belonging to Upper Tertiary and Quaternary age. The Upper Tertiary formations include shale-sandstone sequence belonging to the Athgarh Formation of Upper Gondwana Group. The Quaternary formations include laterites and alluvial deposits[4].

The major part of the city i.e., western and central part are underlain by shale-sandstone sequences of Athgarh Formation. The sandstones are fine to coarse grained, white to grey in colour and feldspathic in nature. These sandstones are at times pebbly, conglomeratic, gritty and ferruginous and are intercalated with greyish white, pinkish and carbonaceous shale and kaoline. The sandstones in general though fractured and friable are also hard and compact at places. The near surface parts of the sandstones are generally partly lateritised. The thickness of the Athgarh Formation in major part of the city is more than 200m. The Quaternary formations comprises mainly of laterites and alluvial deposits. The laterite and lateritic gravels mainly occur in the central and western part as capping over the country rocks. The thickness of laterites on average is around 4 to 5m with the maximum around 12 to 13 m at local pockets. The thick laterite cover generally occurs in the western upland part of the city. The alluvial deposits which include mostly Recent alluvium occurs as thin layers along the extreme eastern part of the city. The maximum thickness is around 30 to 40m and composed of clay, silt and fine to medium coarse sand. The Alluvial deposits are underlain by the Athgarh Formation.

Athgarh Formation : The aquifer systems in this formation at shallow as well as at deeper depths are mainly formed by sandstones. The shale form mainly phreatic aquifers and that also with limited potential. The weathered zone extends down to 12 to 15m and top weathered part down to an average depth of 5 – 6m is lateritised. The yield from the dug wells on an average is around 20 – 25 m^3 / day, if sandstone predominates. The same is around 10 – 12 m^3 / day, if shale predominates. The yield factor in sandstones generally varies from 1 – 2 lpm / m^2 / m of drawdown while the same in shale is less than 1 lpm / m^2 / m of drawdown. The yield from the deeper fractures varies widely and mostly fractured and friable sandstones form the aquifer zones. The wells were drilled down to a maximum depth of 151 m and the yield varied from 1.5 lps to 30 lps with the average around 7 – 10 lps. The fracture zones are generally restricted within 100 m depth. The depth of static water levels vary between 8 – 12 m below ground level during summer and drawdown of water levels during pumping is restricted within 30 m. The specific capacity values ranges from 9.47 to 252.4 lpm / m of drawdown with the average value around 90 – 100 lpm / m of drawdown. The transmissivity values ranges from 15 - 258 m^2 / day with the average around 100 m^2 / day.

Un-Consolidated Formation : This formation includes sand, clay, silt layers which occurs in the extreme eastern part of the city. The thickness varies from negligible to a maximum of 30 – 40 m. The aquifers are mainly formed by the sand layers and may be divided into shallow unconfined and deeper semi-confined aquifers. The yield of the existing dug wells in shallow aquifer on average, is around 40 – 45 m^3 / day and the yield sustains throughout the year without any variation. The yield factor of the alluvial aquifers is generally 2.5 – 3 lpm / m^2 / m of drawdown. The yield from deeper zones which are generally tapped by tube wells depend upon the thickness of alluvial deposit and also on the cumulative thickness of sand zones (medium to coarse sand). On an average 4 – 6 m thick (individual or cumulative thickness) medium to coarse sand layers may yield upto 35 lps with the average yield of 15 to 20 lps. The drawdown of pumping water level is generally within 6 / 7 m and tube wells may be run for 8 – 9 hours in a day and continuously for 3 – 4 hours. The water level in these tube wells generally rests within 4 – 5 m during peak summer.

5.2 Ground Water Resource & Status of Development : The Annual replenishable ground water resource for the master plan area (233 Sq.Km.) has been estimated following the GEC norm,1997 considering the available data on water level fluctuation and specific yield of the formation. Based on the data, average water level fluctuation was considered as 3 m and specific yield as 7.5 %. It is found that the annual replenishable ground water resources is to the tune of 5242.5 Hectare Metre (HaM) for the city master plan area. Due to the absence of precise data the resource of deeper zones could not be estimated, however, this resource (5242.5 HaM) can be taken as annual replenishable resource for both shallow and deeper zones down to 100 m depth because major part of the city area is underlain by semi-consolidated highly fractured sandstone and shallow and deeper aquifers appears to be directly connected. Based on the availability of the aquifer zones at deeper depths down to 100 m and considering the availability of pore spaces(20%) within the aquifer zones and specific yield of 15% for fractured Athgarh Sandstones etc. it appears that annual replenishable ground water resources including deeper zones may be 10% more than that of the estimated figure of 5242.5 HaM. However, at present, the figure of 5242.5 HaM have been considered strictly as the annual replenishable ground water resource. The entire resource may be utilised for domestic purpose as the area under report is Bhubaneswar city[5].

Ground water development is through open / dug wells, shallow and deep bore wells. PHED, Govt of Odisha is the major organization for withdrawal of ground water. PHED generally withdraws 41.6 MLD i.e., 4.16 HaM / Day. Besides this, the dwelling complexes like flats and individual house owners also use ground water where PHED pipe water supply is not available. It has been tentatively estimated that these flats and individual houses, small industries and PHED hand pumps together draws 20 MLD ground water through shallow / deep bore wells and open / dug wells which accounts for 2HaM per day. The total ground water withdrawal is 6.16 HaM per day and annual figure becomes 2248.4 HaM (say 2250 HaM). But it can be assumed here that during rainy season, the withdrawal of ground water is immediately replenished by the rain water. Hence the draft for rainy season which accounts for 549 HaM (6.16 HaM per day X 90 days) is balanced by rainfall and actual draft may hence be assumed to be only 1701 HaM, which is 32.24 % of the available ground water resource. The balance ground water resource is 3541.5 HaM.

5.3 Major Ground Water Related Problems : In general it has been found that the ground water from both the shallow and deeper zones are slightly acidic in nature. The deeper aquifer though in general contain a little higher concentration of iron than that of permissible limit but the dug well water normally does not show any higher concentration beyond permissible limit except in isolated cases as the dug well water remains in constant contact of atmospheric air which facilitates oxidation and precipitation of iron. The analysis data also indicated that concentration of different chemical constituent and pH varies in pre and post monsoon period. A perusal of data revealed that pH is low in majority of the cases and in some cases iron content is high particularly in deeper aquifer water. As per BIS norms the water is fit for drinking purpose except for lower pH value in majority of the cases and high iron content in deeper aquifer in some cases. The pollutants like nitrate and fluoride etc. are generally within the permissible limits, though, higher concentration of nitrate is noticed in some isolated pockets.

5.4 Feasibility of Rainwater Harvesting & Artificial Recharge : The PHED at present utilizes 41.6 MLD of ground water for domestic supply. The expected requirement by 2020 is 422 MLD. Apart from this, there may be additional requirement of water for smooth functioning of city life. The available ground water resource in the city master plan area indicates that ground water can supply 122 MLD maximum considering 85% utilization of the available annual replenishable ground water resources of 5242.5 HaM. Considering the huge requirement of water, steps are to be taken for augmentation of ground water resource by artificial recharge method. Rain water may be used as a source for artificial recharge. The entire rainwater precipitating on the roof top of any building may be collected at one or more place on the ground surface and same may be injected underground through pits, trenches etc. This will facilitate in augmenting ground water resources. The roof top harvesting of rain water should be made mandatory for each building in the city area. Apart from this, surface storage facilities like tanks, lakes, ponds etc. should also be created and / or renovated as far as possible.

6. GROUND WATER DEVELOPMENT STRATEGY

6.1 Augmentation of Drinking Water Supply from existing Ground Water Resources : The PHED presently supplies 206 MLD of water through pipe water supply scheme out of which ground water source is 41.6 MLD. The estimated water requirement for the city by the year 2020 is about 422 MLD at the rate of 150 litres per person per day. Apart from this, there may be additional requirement of water for smooth functioning of city life. The available ground water resource in the city master plan area indicates that ground water can supply 122 MLD maximum considering 85% utilization of the available annual replenishable ground water resources of 5242.5 HaM. The balance requirement which amounts to more that 300 MLD is to be met from other resources like surface water sources etc. However, ground water draft of 162 MLD may be feasible considering the fact that the draft during rainy season does not affect the annual replenishable resource and available resource can be utilized for non-rainy seasons. Under this situation also the balance requirement of 260 MLD of water is required to be arranged from other sources. However, pumping schedules should be clearly be synchronized in different part of the city specially in the high population pockets and in areas with higher density of ground water abstraction structures to reduce the effects of cumulative drawdown. Also people should be encouraged to use dug well water for both potable and non-potable use to reduce the stress on the underlain deeper confined to semi-confined aquifers[6]. The ground water development possibility map is given in figure 2.

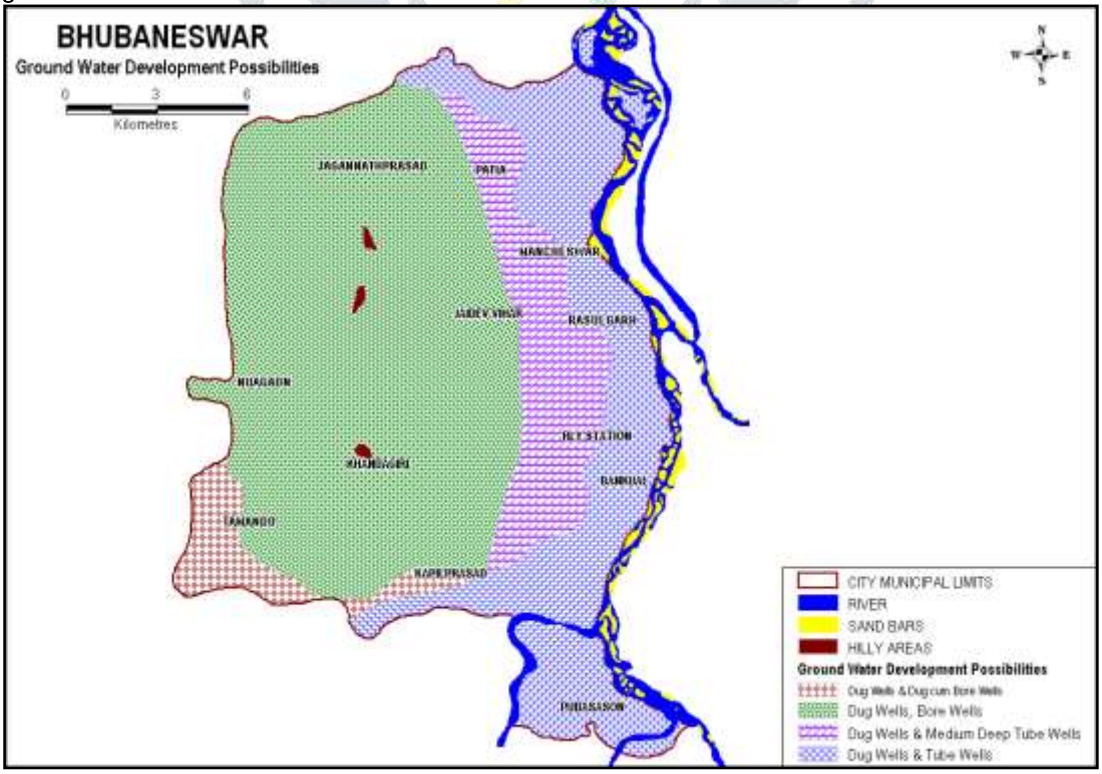

Figure 2 : Ground Water Development Possibility Map of Bhubaneswar City, Odisha

6.2 Augmentation of water resources by water conservation etc : As described earlier there are more than 10 heritage tanks and about 13 man made tanks in Bhubaneswar. These have been the traditional spots for rainwater conservation since time immemorial. In addition to this there are a number of small nallahs, drainage channels, springs. Due to the rapid stress of urbanization, most of these natural drainage channels have now become obscured or blocked. Efforts must be made to demarcate these areas and make them encroachment free. This will improve drainage congestion and restore hydrological equilibrium of the city area. Apart from this, under JNNURM, Bhubaneswar Development Authority undertook steps to study the feasibility of renovation / restoration of old tanks and other water bodies. Once implemented, this will enhance the ground water recharge in the environs and improve both the quality and quantity of the ground water.

6.3 Augmentation of water resources by Artificial Recharge etc : Considering the huge requirement of water, steps are to be taken for augmentation of ground water resource by artificial recharge method. Only rain water should be used as a source for artificial recharge. Besides above, it is very much necessary to keep a vigil on ground water regime of Bhubaneswar city both quantitatively and qualitatively. The ground water level monitoring periodically by construction of piezometers in the city area on a grid pattern should be initiated to reveal the exact ground water scenario in finer detail. Indiscriminate boring, particularly in the municipal area by multi-storeyed dwelling or other complexes should be restricted, otherwise ground water depletion in local pockets may happen. Additionally, proper disposal of huge city garbage should be ensured, so that ground water should not be polluted. This should be checked by Periodic monitoring of ground water quality[7].

Conclusion

In view of the above it is expected that a huge surge of population will live within the city municipal limits. This would in turn trigger an accelerated water consumption which in turn will evolve to an addition dependence ground water and add stress to the existing ground water regime.

Under such circumstances the following measures for artificial recharge is proposed for the city of Bhubaneswar.

1. Roof top rain water harvesting to be made mandatory to all new constructions hence forth. First all the governmental building and infrastructures(existing/ under construction / under consideration) should adopt roof top rain water harvesting. For around 20 such buildings feasibility studies may be undertaken.

2. As per CGWA guidelines, all commercial establishments, hotels, Apartment complexes, Malls etc should mandatory implement a Rain water harvesting scheme which should include a component of Artificial recharge to ground water as well. Around 20 such complexes exist and feasibility studies may be carried out for the same.

3. In all the green belts, in addition to renovating & restoring the existing ground water conservation and storage structures, new cost effective structures may be constructed. On a pro-rata basis it is estimated that an additional 100 such structures are feasible in the city.

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