

To Study Hydrogeology and Wetland-Groundwater Interactions around Sukhna Wetland, Chandigarh, India

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Abstract

In the present paper the hydrological regime around Sukhna wetland is studied to know how a wetland is functioning, its influence on hydrology of the area and wetland-groundwater interactions. The subsurface geology of boreholes drilled around Sukhna wetland reveals thick zones of boulders, pebbles, gravels, sand and clay at different depths. In this area there are two type aquifer systems i.e., shallow and deep. The depth for shallow aquifer ranged 2-20 m bgl and in deeper aquifers ranged 10 above 40 m bgl. The water level fluctuations for the period 1985-2013, indicates the declining water level trend in both the seasons i.e., pre monsoon (May) and post monsoon (November) due to over exploitation by tubewells installed by the Public Health Department, UT, Chandigarh for providing domestic water supply. The water table elevation contour maps for May and November months in Chandigarh for years 1986, 1991, 1999, 2005 and 2012 reveals that the regional ground water flow direction is from Northeast to Southwest and there is no significant temporal variations in regional ground water flow direction. On the basis of hydrological regime study around Sukhna wetland it is inferred that no appreciable rise in water levels has been observed around Sukhna wetland but it is contributing recharge in the upper shallow aquifer system in the central part of Chandigarh and below as the subsurface groundwater flow is towards south and south west direction.

Keywords: Wetland; Groundwater; Sukhna; Hydrology

Introduction

Wetlands are important ecosystems which perform wide range of hydrological functions such as groundwater recharge and discharge, flood flow alterations, sediment stabilization, water quality etc. [1]. They act like a sponge, soak up water during wet period and release up during dry period [2]. The understanding of hydrological regime and wetland-ground water interactions around any wetland is important. It helps in knowing how a wetland is functioning, its influence on hydrology, hydrochemistry and ecology of the wetland [3]. The hydrology around wetland is strongly influenced by the geological framework, depth and groundwater flow direction below the wetland basin [4]. The permeability of geologic deposits and ground water-surface water flow pattern around wetland directly affect the wetland-groundwater exchange and indirectly it affects the magnitude of runoff received from the surrounding upland areas [5]. The groundwater-surface water interaction processes are based on the concept of hydrological connectivity [6,7]. This refers to physical linkage of water with rivers, wetlands and surrounding catchment [6,8]. This connectivity allows the exchange of water, solutes and dissolved matter [8,9]. The understanding of hydrogeology and wetland-groundwater interactions around Sukhna wetland is important for an effective management of this surface water resource. The present paper provides an overview of subsurface geology, aquifer system, depth to water tables, water level fluctuations, ground water flow pattern and wetland ground water interactions around Sukhna wetland.

Study area

Sukhna wetland is located within the city beautiful Chandigarh which is surrounded by Siwalik hills (Figure 1). It came into existence in year 1958. It is a manmade freshwater wetland, which is mainly fed by the seasonal rainwater. It is roughly kidney shaped. The mean depth of Sukhna wetland is 3.3 m and maximum depth of 5.5 m whereas the length is 1.52 km and width is 1.49 km.

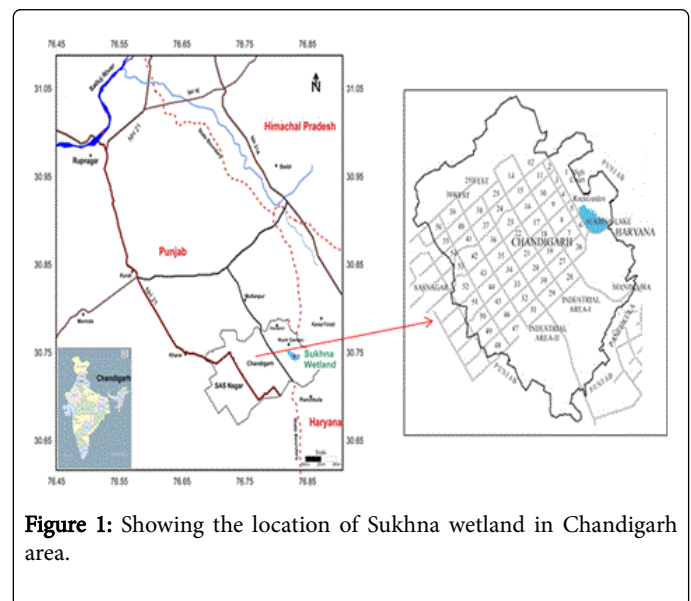


Figure 1: Showing the location of Sukhna wetland in Chandigarh area.

The wetland has a catchment area of 42.07 Sq km, of which 29.08 Sq km falls in the Union Territory of Chandigarh, 10.22 Sq Km in Haryana and 2.77 Sq km in Punjab [10]. The climate of Sukhna wetland has mean maximum temperature of 39.1°C during June to minimum temperature of 6.1 °C during January. The average annual rainfall of the area is 1061 mm [11].

Geology and geomorphological features

The regional geological map (Figure 2) around Sukhna (Chandigarh) reveals that rocks of Siwalik system (lower, upper and middle) are exposed in the north east parts of the wetland. Lithologically, these are loose sand stone and silt stone which give rise to sandy and silty soils in the area. The catchment area of Sukhna wetland has rugged terrain, steep slopes and characterized by gully erosion [10].

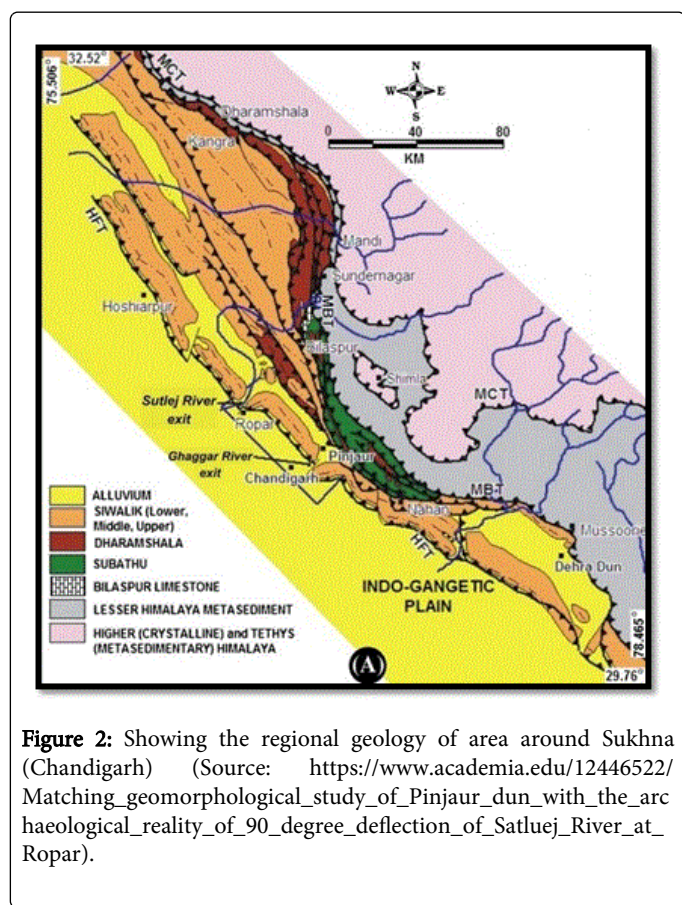


Figure 2: Showing the regional geology of area around Sukhna (Chandigarh) (Source: https://www.academia.edu/12446522/Matching_geomorphological_study_of_Pinjaur_dun_with_the_arc_haeological_reality_of_90_degree_deflection_of_Satluej_River_at_Ropar).

The detailed geological map (Figure 3) of area around Sukhna wetland in Chandigarh area shows that Sukhna wetland is located over the older alluvium (Q1) of middle to late Pleistocene age. The older alluvium comprises red soil, mixture of clay, silt and sand with kankar, grey medium to coarse micaceous sand with kankar embedded with clay and silt. The newer alluvium (Q2a and Q2b) of Holocene age is confined to areas around Sukhna choe (Figure 3).

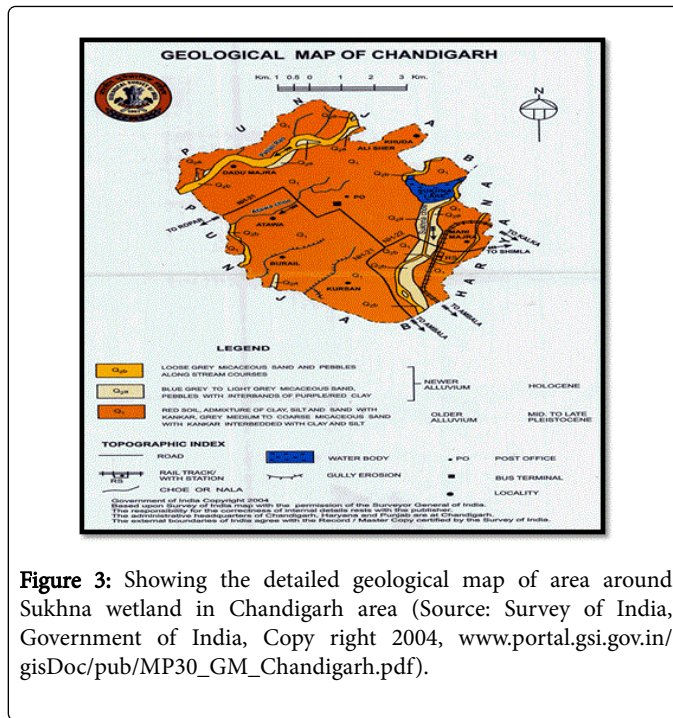


Figure 3: Showing the detailed geological map of area around Sukhna wetland in Chandigarh area (Source: Survey of India, Government of India, Copy right 2004, www.portal.gsi.gov.in/gisDoc/pub/MP30_GM_Chandigarh.pdf).

Methodology

Data collection

The data was collected from different organizations to study hydrogeology around Sukhna wetland. Some unpublished reports were collected from Central Ground Water Board, Chandigarh [11] to know the water level depth, existing aquifer systems, aquifer characteristics and overall hydrogeological regime around the study area. Year wise water level data was collected from Central Ground Water Board, Chandigarh for different sites in the Chandigarh (from period 1985 to 2013) to monitor water level fluctuations.

Data analysis and mapping

The lithologs for different bore wells was prepared in Rockwork software. The water level data from period 1985 to 2013 in Chandigarh area was analyzed in an excel spread sheet for monthly and annual values for each bore well site. The hydrographs were plotted for May month (Pre monsoon period) and November month (post monsoon period) using word excel chat for the study area. The elevation contour maps were processed in Surfer 12 to study the ground water flow in the study area.

Results and Discussion

To understand the hydrogeological regime and wetland-ground water interactions around Sukhna wetland, the subsurface geology, aquifer system, depth to water tables, water level fluctuations and ground water flow pattern in Chandigarh area are studied and discussed below:

Subsurface geology

Chandigarh city is occupied by semi consolidated formations of upper Siwalik system of middle Miocene age exposed in the northeastern parts. The piedmont deposits lying at the foothills of Siwaliks, comprise of cobbles, pebbles, boulders associated with sand, silt and clay. The piedmont deposits are followed by alluvial plains in the southern parts comprising finer sediments such as sand, silt and clay [11].

The subsurface geology of boreholes drilled around Sukhna wetland i.e., near high court area, sector 6, sector 1 and Kaimbala has been examined and lithologies of these boreholes are shown in Figure 4. The borehole data indicates that area is underlain by boulders, pebbles, gravels, sand and clay. In the top, the sub surface lithology is dominated by thick zones of boulders, pebbles, gravels, sand and clay ranging in thickness from 3 to 5 m upto the depth of 80 to 85 m. This lithology is followed by the thick clay bed at 95 to 145 m depth having thickness of about 15 m. Below 145 m depth, again the zones of sand, boulders, gravels and clays occur which have thickness varying from 2 to 8 m. All the boreholes examined around Sukhna wetland show similar sub surface geology with minor variations. The depth to static water level ranges from 50 to 80 m bgl in these drilled boreholes.

The subsurface lithology of Chandigarh area based on exploratory drilling carried out by Central Ground Water Board also reveals similar lithology with minor variations. Central Ground Water Board [11] has also depicted three prominent sand beds which occur (inter-bedded with clay beds) within a depth of about 100 m along the Sukhna choe. The upper sand bed is about 15 m thick and occurs 8 m below the land surface. Middle sand bed is about 18 m thick and occurs at depth varying from 21 to 38 m bgl. The deeper sand bed occurs at depth varying from 39 to 76 m bgl and is about 27 m thick [11]. These beds are more persistent in the downstream direction of Sukhna wetland. The similar lithology has been observed in the sector 6 bore hole well (Figure 4) which is close to Sukhna wetland.

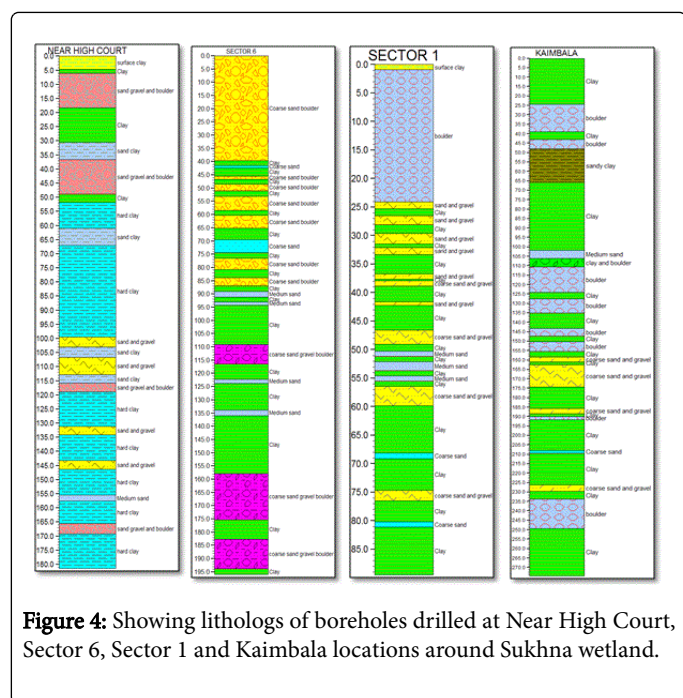


Figure 4: Showing lithologies of boreholes drilled at Near High Court, Sector 6, Sector 1 and Kaimbala locations around Sukhna wetland.

Aquifer system

In Chandigarh area, there are two distinct aquifer systems - shallow and deep. The shallow or upper aquifers are generally unconfined upto 80 m bgl in Manimajra area as revealed by drilling data of CGWB [11]. In the other parts of the city the semi confined conditions prevail upto 20-30 m below the land surface. Deeper confined aquifers exist below 90 m bgl in Manimajra which is close to Sukhna wetland [11].

In Chandigarh, the aquifer performance test conducted by Central Ground Water Board [11] reveals that transmissivity ranges from 74 to 590 m²/day for deeper aquifer system (100-300 m depth). In shallow aquifer upto 100 m depth it ranged from 70 to 466 m²/day [11]. The storativity of deeper ranged between 1.5 × 10⁻⁴-7.5 × 10⁻⁴, indicating confined nature of aquifer system [11].

Depth to water table

The Figures 5A and 5B indicates the water level depth for deep and shallow aquifer in Chandigarh. The depth to water level during pre-monsoon season in the shallow aquifer varies between 2 to above 20 m bgl (Figures 5A) whereas in the deep aquifer system the water level lies between 10 to above 40 m bgl (Figure 5B) [11]. Sukhna wetland lies in the northeastern side of Chandigarh where depth to water level for shallow aquifer ranged above 20 m bgl and in deeper aquifers ranged above 40 m bgl [11].

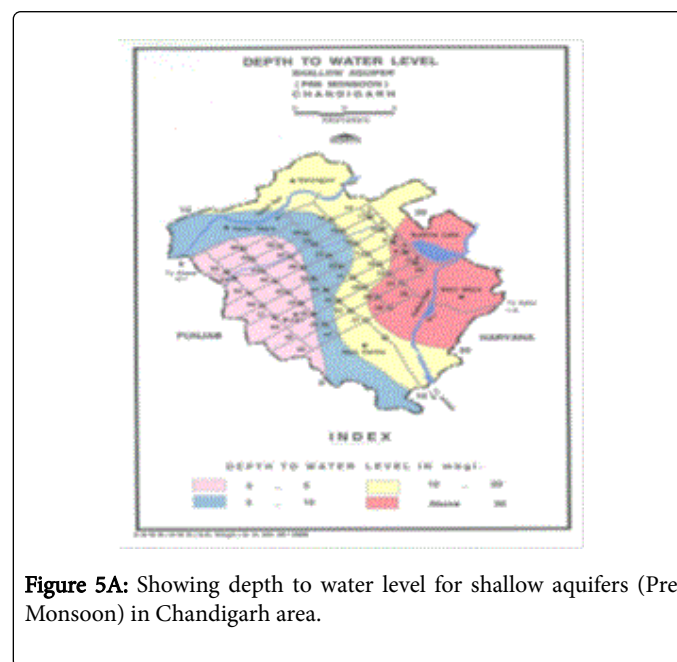


Figure 5A: Showing depth to water level for shallow aquifers (Pre Monsoon) in Chandigarh area.

8	Sector 39 D	19.03	30.42
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Table 1: Showing the rate of fall/rise in water levels in observation wells located near to Sukhna wetland.

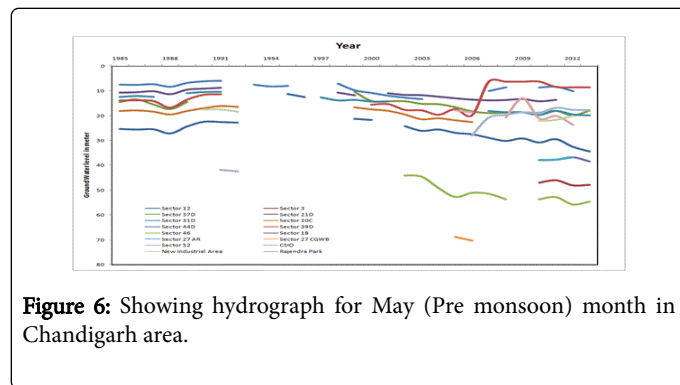


Figure 6: Showing hydrograph for May (Pre monsoon) month in Chandigarh area.

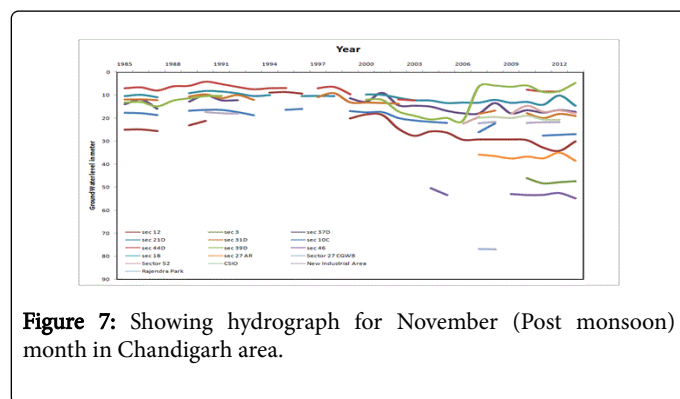


Figure 7: Showing hydrograph for November (Post monsoon) month in Chandigarh area.

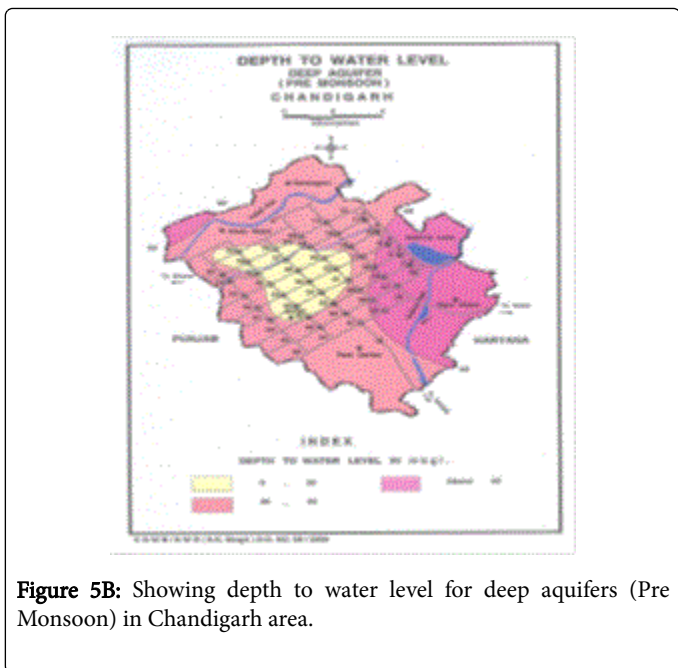


Figure 5B: Showing depth to water level for deep aquifers (Pre Monsoon) in Chandigarh area.

Water level fluctuations

The long term water level fluctuations for two seasons i.e., May (Pre monsoon) and November (Post monsoon) months has been studied in Chandigarh area. The hydrographs plotted (Figures 6 and 7) for May month (Pre monsoon) and November month (Post monsoon) reveal the declining trend in water level in deep aquifers in most of the observation wells and it is attributed due to the over exploitation of groundwater by tubewells installed by the Public Health Department, UT, Chandigarh for providing domestic water supply. Table 1 shows the rate of fall/rise in water levels in observation wells near to Sukhna wetland in Chandigarh area for the period 1985-2013 which indicates that in all the locations the water levels are declining except in sector 39 D well, where the water level is showing the rising trend due to local variations. On the whole, the water levels in the study area show the declining water level trend.

S No	Location	Rate of fall/rise in water level (cm/year) [From 1985-2013]	
		May (Pre Monsoon)	November (Post Monsoon)
1	Sector 12	-32.28	-18.21
2	Sector 3	-81.21	-73.6
3	Sector 37 D	-12.32	-11.96
4	Sector 21 D	-16.82	-25.39
5	Sector 31 D	-26.78	-25.39
6	Sector 10 C	-34.35	-32.78
7	Sector 44 D	-9.28	-4.96

Water table elevation contours

The water table elevation contour maps for May and November months in Chandigarh are shown in Figures 8A and 8B for years 1986, 1991, 1999, 2005 and 2012. These maps reveal that the regional ground water flow direction is from northeast to southwest. Further, the regional groundwater flow direction does not show any significant temporal variations.

Wetland-groundwater interactions

On the basis of hydrogeological regime discussed above, it can be inferred that Sukhna wetland is contributing recharge in the upper shallow aquifer system as revealed by water table contour maps prepared. The water table contour maps (Figures 8A and 8B) reveal the groundwater flows from Sukhna wetland area towards the central part of Chandigarh and below. However, no appreciable rise in water levels has been observed in upper shallow aquifer around Sukhna wetland as the subsurface groundwater flow is towards south and south west directions and exploitation of groundwater by shallow tube wells. Deeper aquifer system is not influenced by the Sukhna wetland and water levels of this aquifer system show declining water level trend due to over exploitation of groundwater by water supply tubewells installed by the Public Health Department, UT, Chandigarh for domestic use.

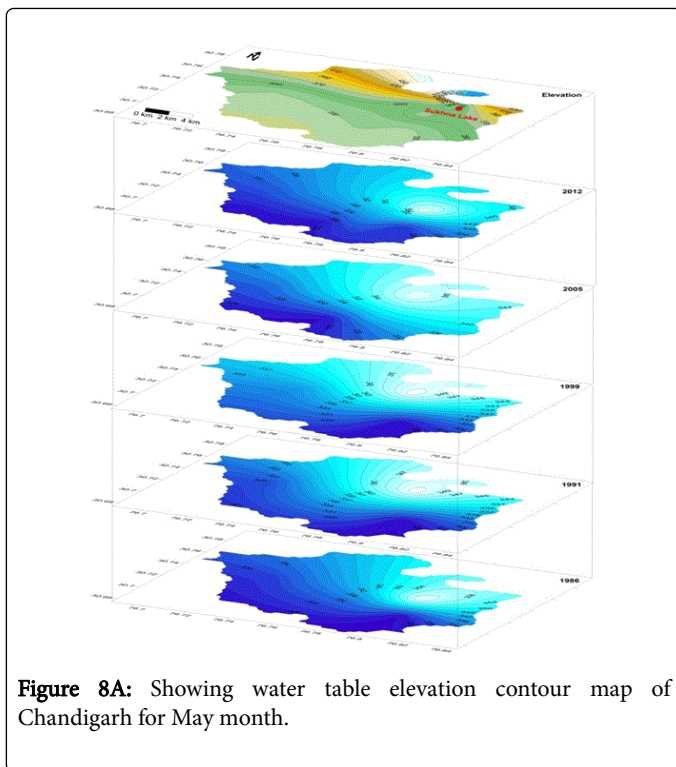


Figure 8A: Showing water table elevation contour map of Chandigarh for May month.

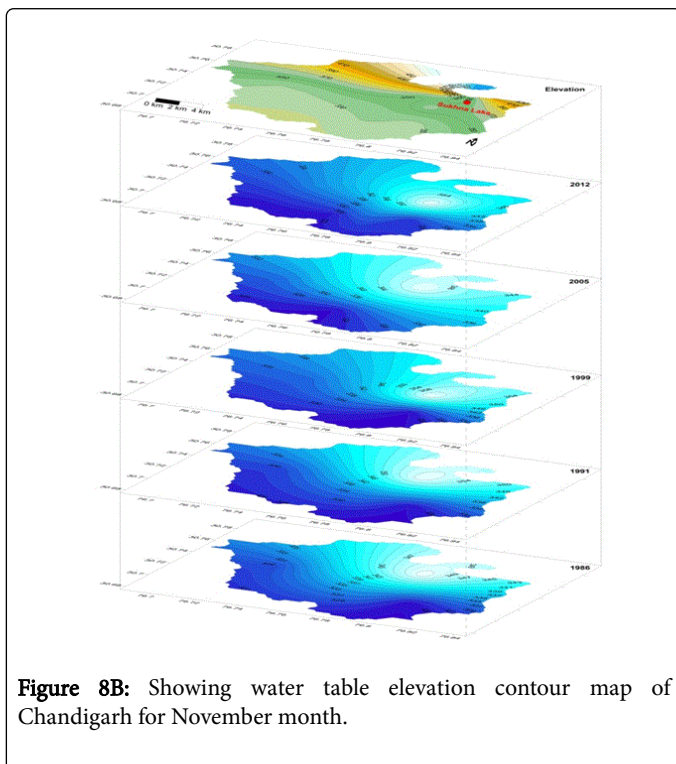


Figure 8B: Showing water table elevation contour map of Chandigarh for November month.

Conclusions

The subsurface geology of boreholes drilled around Sukhna wetland i.e., near high court area, sector 6, sector 1 and Kaimbala indicate that area is underlain by boulders, pebbles, gravels, sand and clay. In the top, the sub surface lithology is dominated by thick zones of boulders,

pebbles, gravels, sand and clay ranging in thickness from 3 to 5 m upto the depth of 80 to 85 m. This lithology is followed by the thick clay bed at 95 to 145 m depth having thickness of about 15 m. Below 145 m depth, again the layers of sand, boulders, gravels and clays occur which have thickness varying from 2 to 8 m. All the boreholes examined around Sukhna wetland show similar sub surface geology with minor variations. There are two type aquifer systems i.e., shallow and deep. The depth for shallow aquifer ranged 2-20 m bgl and in deeper aquifers ranged 10 above 40 m bgl in study the area. The water level fluctuations for the period 1985-2013, indicates the declining water level trend in both the seasons i.e., pre monsoon (May) and post monsoon (November) due to over exploitation by tubewells installed by the Public Health Department, UT, Chandigarh for providing domestic water supply. The water table elevation contour maps for May and November months in Chandigarh for years 1986, 1991, 1999, 2005 and 2012 reveals that the regional ground water flow direction is from Northeast to Southwest and there is no significant temporal variations in regional ground water flow direction. On the basis of hydrological regime study around Sukhna wetland it is inferred that no appreciable rise in water levels has been observed around Sukhna wetland but it is contributing recharge in the upper shallow aquifer system in the central part of Chandigarh and below as the subsurface groundwater flow is towards south and south west direction. It is recommended to keep a regular check on the over exploitation of groundwater around Sukhna wetland and areas around it.

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