Mitigating the Anthropological Impacts on The Sukhatal Lake: A Feasibility study into dredging the Sukhatal Lakebed

Project Background

On the 17th July 2014, in an attempt to find a solution to the escalating degradation of the Nainital Lake in the Uttarakhand Province of India, a court order was passed to remove encroaching settlements from the perimeter of the lake. The court order demands that all settlement on any of the 22 'nalas', (inflow drains), be removed immediately. Additionally, a complete ban of polythene use in the Nainital area has been introduced and any permanent or temporary construction within a 30m radius of the lake has been made illegal. At the time of writing, the High Court of Nainital was in the process of deciding whether to demolish some 50 properties, several constructed legally, several illegally, that directly contribute to the annual reduction in the volume of water held in the Nainital basin. These constructions, the majority of which are the homes of low-income families, lie on the dry-lakebed, named Sukhatal, which is responsible for 19.5% of the total inflow into Nainital Lake. This report will look into the effects of the construction on the Sukhatal Lakebed on the groundwater recharge flow from Sukhatal to Nainital. Additionally, a feasibility study of dredging the Sukhatal Lake in order to provide a viable alternative to demolishing these abodes will be presented.

Nainital Town

Officially founded in 1841 with the construction of the first property by English sugar trader Peter Barron, today Nainital is one of the most significant tourist attractions in the Indian Himalaya region. In the last two decades, the population of Nainital has soared, putting intense pressure on the limited natural water resources provided by Nainital Lake. The 2011 Census of the Nainital District put the population of the entire district at 954,605, a 25.13% increase from 2001 (Census, 2011). This population encompasses the several towns that are situated in the Nainital District. The population of the Nainital community that is based around the Nainital Lake has been estimated to be approximately 50,000. The influx of tourists in the region, of which the majority arrive in the summer months, has been

estimated to be as much as 400,000 per year (Gopal, Singh, 2002). This degree of oscillating population has put massive strain on Nainital's infrastructure leading to significant water quality degradation, vehicle congestion on the roads and unregulated urban sprawl.

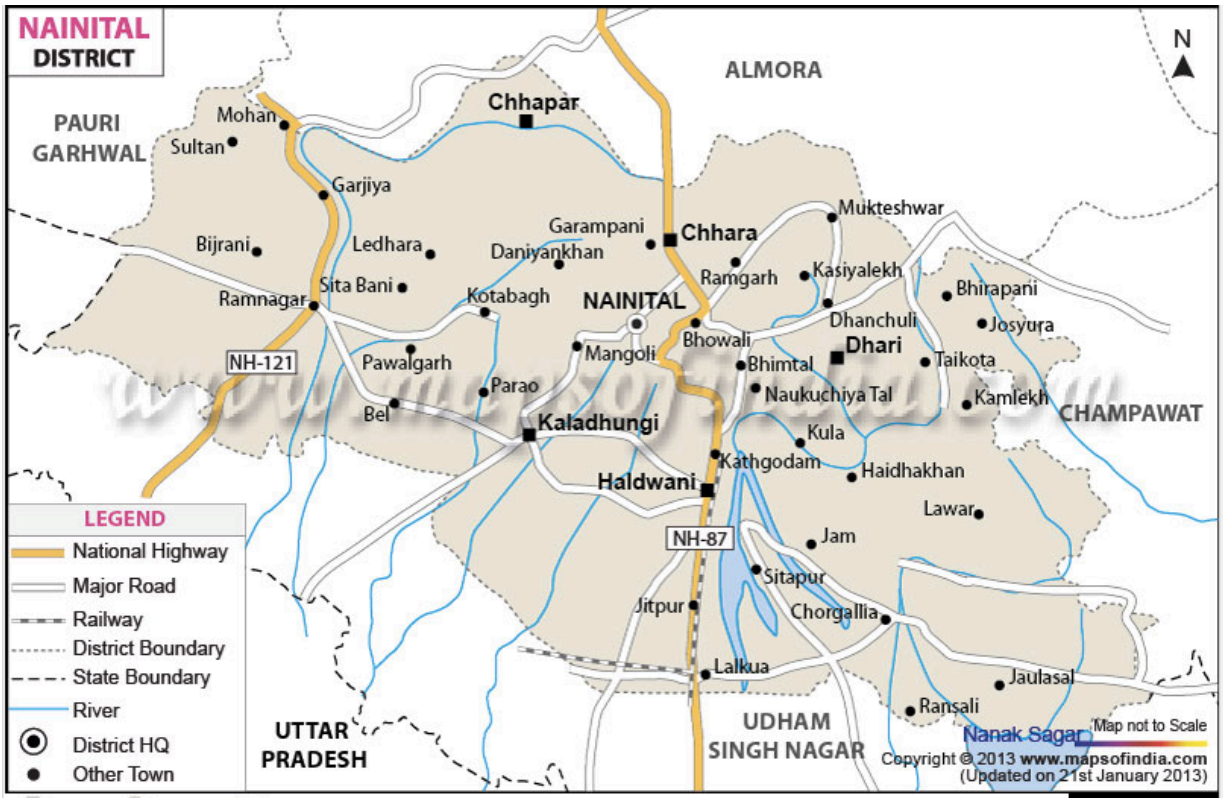

Figure 1 - Settlements in the Nainital Area courtesy of 'Maps of India'

Over a decade of illegal construction has lead to a significant decline in water quality as settlement on top of the inflow channels has lead to both organic and plastic pollution flowing directly into the Nainital Lake. Not only is the lake visually polluted; plastic bags, bottles, and even discarded shoes litter the shores, but there is also significant levels of sewerage reaching Nainital Lake.

Nainital Lake Dimensions

In a study carried out by the Indian Institute of Hydrology in 1999, the maximum volume of the Nainital Lake was estimated to be approximately 8,581,714 m^3. The report states that the lake has a maximum length of 1.4km, maximum width of 0.45km, maximum depth of 27.3m and mean depth of 18.52m. The surface area of the lake is 48ha and the annual rainfall in the area is approximately 200-250mm. The study shows that in the year of 1994, the lake level

varied by 1.2m between its lowest height in June and it's highest in October directly after the monsoon season. 21 drains, springs, runoff and subsurface inflows lead to Nainital Lake. The lake catchment is characterised by a significant number of faults and fractures, which coincide with the surface drains. The natural flow of the groundwater to Nainital follows the path of these faults and fractures. Below is a drainage map of Nainital provided by Valdiya, 1988. Red lines represent fractures and blue lines represent major faults.

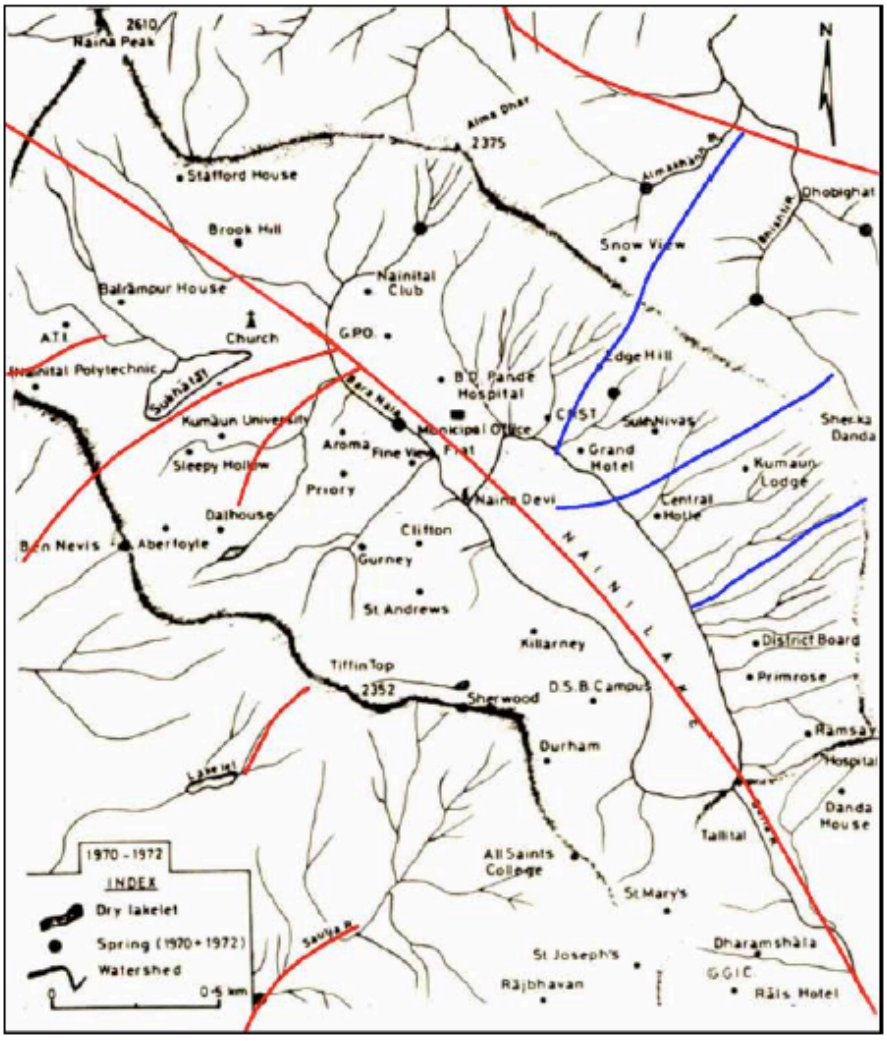

Figure 2- Faults of the Nainital Lake Region

The total area of the Nainital watershed is 14.32km^2 (Gopal, Singh, 2002). Of this value, approximately 20% is covered by construction. The replacement of natural vegetation by an urban environment has lead to increased levels of surface runoff as concrete is far less permeable than soil. The result is that a larger proportion of water reaches Nainital Lake as surface runoff, rather than through groundwater recharge. The underground strata acts as a

natural form of filtration, whereas surface runoff receives no such filtration and is far more vulnerable to contamination as it is channelled through open drains.

An estimated 15.45 million litres per day is extracted from the Nainital Lake to serve the local population. 40% of this is extracted directly from the Nainital Springs and natural sub-surface flow provides the other 60%.

Environmental Degradation of the Nainital Area

Two decades of illegal construction directly on top of the inflow channels that lead into Nainital have lead to a significant decline in water quality. As far back as 1988, the lake water was exhibiting signs of advanced pollution. A study carried out by K.S Valdiya stated that,

'The shallowing lake is showing signs of prolific growth of weeds, diminishing transparency, phenomenal increase in the amounts of phosphates, ammoniacal nitrite and nitrate, increase in the content of carbon dioxide, rising hardness and reduction in the proportion of oxygen dissolved in the lake water'.

Water quality degradation is not the only issue. The water level in Nainital Lake follows a pattern of natural increase and decline in response to increased rainfall in the summer months. However, over the last two decades, the high water level has gradually decline due to over-abstraction, increased activities and movements within the catchment affecting surface runoff to the lake, and a reduction in water recharge from Sukhatal to Nainital Lake. Additionally, the overall volume of the lake is decreasing due to detritus filling the lake from an accelerated pace of erosion. Underwater topography compared in 1899, 1969 and 1979 indicates that the volume of the lake is decreasing at a rate of 70m^3 per year. At the current rate, the lake will be entirely filled in within 400 years (Valdiya, K.S, 2988).

Figure 3 - Sukhatal Lake outlined in blue, Nainital Lake outlined in red

According to the document 'Lake bank Filtration at Nainital, India: Water Quality Evaluation,

'Buildings around the lake have increased from 4,053 in 1971 to 7,836 in 1991' There are no major industrial activities in the catchment area. The land-use classification in the catchment area is: forests and shrubs (42%), buildings (41%), roads (2.1%), water bodies (10.3%), playground (1.1%), and barren lands (3.5%)' (Nachiappan et al. 2002).

Since 1991, the rate of development in the Nainital area has accelerated even further and the perimeter of the Nainital Lake area is quite literally at saturation point. Nainital's sewerage system is over 70 years old and has not been designed to cater for the 50,000-strong population. As a result, the sewerage drains often overflow into rainwater channels that lead directly into the lake. Prior to 1955, water supply had been drawn from the Pardah Spring, however increased demand due to population growth led to water being directly abstracted from the lake. In 1985, a treatment plant was constructed to the northwest of the lake to supply drinking water. When population increased further, 7 tube wells were installed adjacent to Nainital Lake. In 2007, 24.1ML/day was being extracted from these seven tube wells (Dash, R.R 2008).

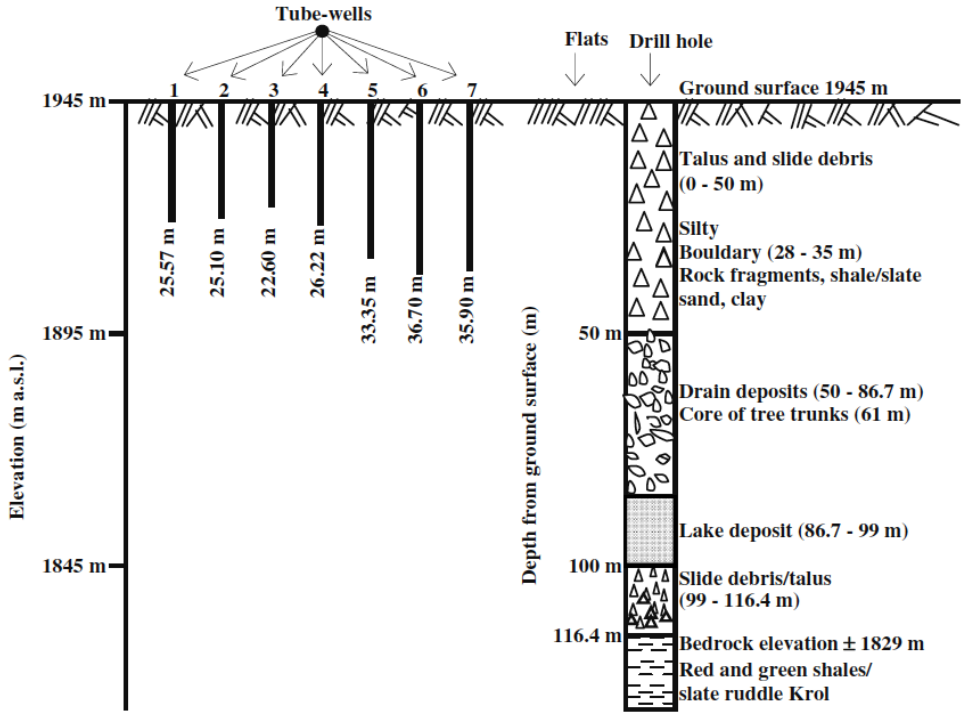

Figure 4 – Location of water provision tube wells in the Nainital Area. Courtesy of Indian Institute of Technology, Roorkee

A water quality evaluation carried out in 2007 by the Indian Institute of Technology Roorkee, analysed the water quality of tube wells 1 to 5 and compared it to the water quality of samples taken from 12 locations in Nainital Lake. The majority of the water that supplies the aquifer that is tapped by these 5 tube wells is provided by groundwater recharge from the Sukhatal Lake. The figure below demonstrates the ratio of water quality between the tube wells and the main body of the Nainital Lake.

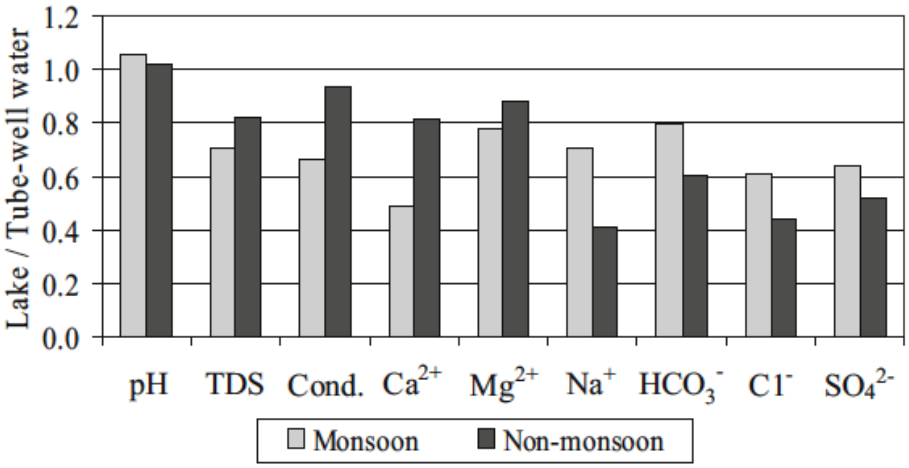

Figure 5 – Water quality comparison between Nainital main Lake and water from the aquifer supplied by Sukhatal Lake. Courtesy of Indian Institute of Technology, Roorkee

Figure 5 clearly shows that, for all criteria, the water quality tapped from the aquifer is of higher quality than the water extracted directly from the Nainital Lake. Figure 6 below demonstrates the ratio of the total and faecal coliform counts in Nainital Lake to those in the main aquifer.

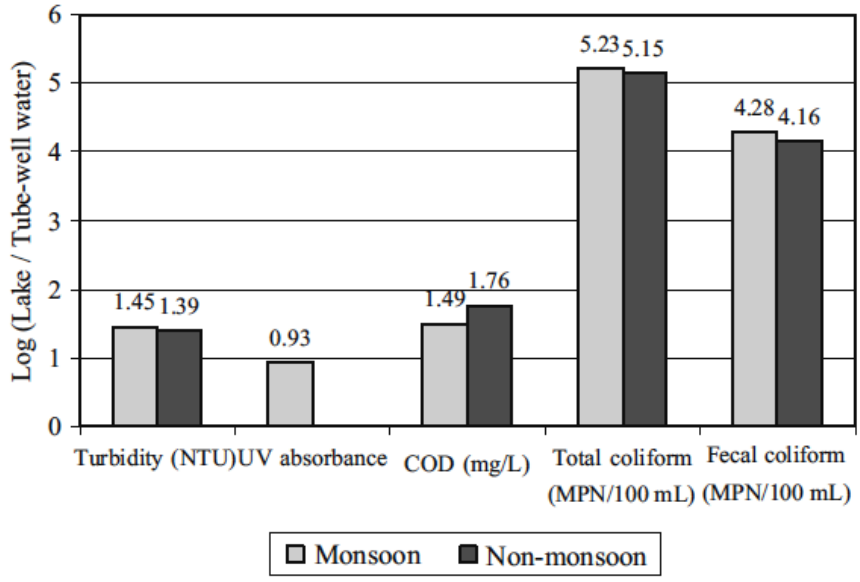

Figure 6 - Water quality comparison between Nainital Lake and main aquifer. Courtesy of Indian Institute of Technology, Roorkee

Figure 6 demonstrates that water tested from the main lake has over four times the concentration of faecal coliforms in comparison to water tested from the main aquifer. The test results highlight the importance of sustaining the groundwater recharge from Sukhatal to Nainital, not only to maintain the high-water level of the lake but also to ensure the water quality of the aquifer tapped by wells 1-7.

When water passes through the natural strata beneath the Sukhatal Lake, the structure of the sub-strata acts as a natural form of filtration. In contrast, when water is fed to Nainital Lake through aboveground open channels, it is far more vulnerable to pollution.

References

Alhassan, M. (2012) Effects of Municipal Solid Waste on Geotechnical Properties of Soils International Journal of Environmental Science, Management and Engineering Research Vol. 1 (5), pp. 204 - 210, Sept. - Oct 2012.

Banerjee M.D, Cristie-Blick N, Kaufman, A. J, Jiang G, Rai V, (2002) Sequence Stratigraphy of the Neoproterozoic Infra Krol Formation and Krol Group, Lesser Himalaya. Journey of Sediment Research.

Census, (2011) Nainital District Census Data [Accessed 09/09/14] Available from http://www.census2011.co.in/census/district/584-nainital.html
Dash R. R, Grischek, T. Kumar P. Mehrotra, I. (2008) Lake bank filtration at Nainital, India: Water-quality Evaluation.

Dash, RR, Grischek T. Kumar P. Mehrotra I (2008) Lake bank filtration at Nainital, India: water-quality evaluation Indian Institute of Technology Roorkee.

DMMC (2011), Slope Instability and Geo-Environmental Issues of the areas around Nainital. Disaster Mitigation and Management Centre, Uttarakhand.

Gopal, B. Singh, S.P Integrated Management of Water Resources of Lake Nainital and its Watershed: An Environmental Economic Approach.

Gupta, A (2008) Late Quaternary Vegetation and Climate from Temperate Zone of the Kumaun Himalaya, India Birbal Sahni Institute of Palaeobotany.

Kumar B, Manickavasagam R, Nachiappan RP (2002) Estimation of sub-surface components in the water balance of Lake Nainital (Kumaun Himalaya, India) using environmental isotopes. Hydrol Sci J 47:41–54.

National Institute of Hydrology (1999) Water Balance of Lake Nainital, Kumaun Himalayas, U.P Jal Vigyan Bhawan.

Ramprasad C. Sujatha E. R. (2013) Effect of Dumping Municipal Solid Waste on the Geotechnical Properties of the Soil. Indian Geotechnical Conference. Roorkee.

Singh, S P (2002) Integrated Management of Water Resources of Lake Nainital and its Watershed: An Environmental Economics Approach. Kumaon University, Nainital Brij Gopal Jawaharlal Nehru University, New Delhi. Environmental Economic Research Committee.

Shan, H (2012) Hydraulic Conductivity Tests for Soils. Dept. of Civil Engineering National Chiao Tung University.

Sujatha E. R. (2013) EJGE Impact of Municipal Solid Waste Dumping on the Geotechnical Properties of Soil and Ground Water in Ariyamangalam, Trichy, India.

Valdiya, K.S (1999) Geology and Natural Environment of Nainital Hills, Kumaun Himalaya Gyanodaya Prakashan, Naini Tal.