Impact of Soil Conservation Measures in the Catchment of Sukhna Lake on Ground Water, Soil and Geology

Submitted to:

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Executive Summary

Foothills occupy one third of the global land surface and are always associated with environmental degradation and ecosystem instability. The Shivalik foot-hills covering 4.2 million hectare area in north India are no exception. They constitute one of the seven most degraded eco-systems of the country. These low hills of recent origin are composed of one of the most erodible soils of the world. These young, fragile, heterogeneous mud-hill formations remained covered with thick forests for centuries. In the last 400 years, protective vegetation cover was destroyed by human needs and greed which triggered the phenomenon of mass soil erosion under the impact of intense monsoon rains. Without adequate vegetation cover, they erode 30 times faster than the Rocky Mountains. The damage caused by flash floods from more than 100 ferocious torrents, loss of productivity, wastage of fertile top soil and precious rainwater remained cause of concern for Punjab much before independence and thereafter as well. The problem of Sukhna Lake siltation also emerged from such a process of heavy soil erosion in its catchment area forming one of the most difficult parts of Shivaliks of North India.

Sukhna Lake of the city beautiful was constructed in 1958 across Sukhna *Choe* and formed integral part of master plan of Chandigarh and became a major tourist attraction. The man-made lake was formed by constructing a 12.8 meter high rock-fill earthen dam and a three-span spillway. At the time of its construction, the storage capacity of the lake was 10.74 Million Cubic Meter (MCM) with water spread area varying between 1.52 and 2.28 Sq Km. The Lake 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. The pre-mature siltation of the lake became a cause of serious concern. Intensive soil and water conservation measures were taken up in the 2540 hectare forest catchment of the lake which included effective closure, large scale plantation, construction of more than 180 silt detention earthen dams and equal number of masonry check dams supported by vegetative conservation measures. These measures systematically taken over a period of almost three decades reduced the siltation rate of the lake from more than 140 to less than 5 tonnes/hectare/year. But no systematic studies were conducted on such impacts. The present study was commissioned in 2007-08 to evaluate the impact of soil conservation measures in the catchment of Sukhna Lake on the ground water, soil and geology. The study was conducted by SPACE-the Society for Promotion and Conservation of Environment, a Chandigarh based NGO registered as a professional group with specialization in Soil and Water Conservation.

The severity of soil erosion problem in its Shivalik catchment was not well realised before the lake was planned. The lake started silting from first year of its formation. The upper areas of Kansal, Nepli and Ghareri *choe*s feeding the lake were extremely denuded, degraded and silt loads were so high that by the time remedial measures were initiated, lot of silt had already found its way to the lake.

The preventive steps in the catchment of Sukhna Lake were initiated in early sixties with the acquisition of present 32.42 Sq. km. of area in phases from 1962 to 1966. Numerous studies suggest that Shivaliks are very difficult to handle. There were hundreds of deepening and widening gullies and frequent landslides which made it different to sustain tree plantation. It was therefore, decided to go in for intensive soil and water conservation measures including silt detention dams along with tree plantation and effective closure ensured by fencing the area

The real ecological recovery in the treated area started in early nineties. This was the result of systematic soil conservation measures taken after proper diagnosis of the problem which included construction of earthen silt retention dams, masonry check dams, gully bed grade stabilizers, vegetative barriers, mechanical spurs and construction of contour trenches etc. The role played by these structures could be understood from the fact that more than 50% of these got filled up by silt in the first year itself. Lakhs of cubic meters of silt was retained and got stabilized in the forest area by these structures which otherwise would have gone to the Sukhna lake. In spite of difficulties posed by terrain, a very high rate of success of plantation was achieved due to improvement in moisture regime and control of biotic pressure and forest fires.

As a result of various soil & moisture conservation works and afforestation, most part of the catchment is stabilized and is now covered under thick vegetation cover. This is substantiated by the data that siltation rate was more than 140 t/ha/yr before taking up these measures but it gradually decreased to 6-9 h/t/yr and more recently between 1-3 t/ha/yr. The ameliorative effects are highlighted as under

- The physical & chemical properties of soil has improved in terms of lower pH, increased phosphorus & potash (116.63 to 219.71 kg/ha) availability and organic matter build up (from 0.44 to 0.70%). The reduction in soil pH is attributed to ameliorative effects manifested through improved soil moisture, increase in organic matter, improved root respiration & biological activities in the rhizosphere. The litter accumulation on forest floor contributed in reducing soil erosion and improving biological activity in surface soil.
- The effective closure and intensive soil & moisture conservation measures carried out consistently for three decades helped in reversal of degradation process & resulted in visible /significant improvement of vegetation cover. The overall tree density improved from 162 to 450 trees/ha and bush density from 5977 to 8994/ha. However, the shade provided by the trees & bushes reduced the number of grass clumps. But due to thick vegetation cover, the leaf litter accumulation on forest floor increased from 2.05 to 4.40 tonnes/ha which resulted in increase of soil organic carbon. The natural regeneration of tree species is seen affected by wildlife browsing, invasion of weeds, and at places by shade. The prominent tree species are A. catechu, A.nilotica, D.sissoo, A.modesta, P.juliflora, A.latifolia and bush species of Lantana, Carripatta, Karonda, Adathoda vasica and Zizyphus. Lantana

was removed from some safe slopes but at places it is again regenerating. Efforts need to be carried out to promote the growth of palatable grasses for wildlife.

- The U.T Forest Department constructed more than 180 earthen dam and almost equal number of masonry check dams for silt retention. All these structures are stable & functioned very well. At present, it seems that Sukhna Lake catchment area is floating on water. There is round the year flow in main drainage lines. Water is just a meter deep in many old wells inside the Sanctuary area. It appears that there is an imperious soil layer down below at a depth of 3to4 meters from the ground which is not allowing deep percolation of basin water. Perennial flow continues towards the lower area in the *choes* but water suddenly disappears as it comes close to the boundary. It is reported that ground water level in the nearby villages in the range of 35-40 meters. Further the deep bores up to 140 meter of large number of tube wells installed in the peripheral area are lowering the water table. Weather the major part of water stored in perched water table is consumed by large number of Eucalyptus trees and other vegetation and or some part slips to deeper aquifers is a subject of very detailed geohydrological investigations. The fact is that the impact of the surface runoff harvesting by all conservation measures is not reflected in the rise of ground water table in the outer periphery of the lake because, large number of deep tube wells have come up in this area and they appear to have negated the impact of recharge by drawing out much more water than added to the ground water by these measures.
- We strongly defend what was done after realization and diagnosis of the real problem. The package adopted was most appropriate. There was no way to halt the march of silt from denuded steep mud hills particularly when heavy soil, rich in silt and clay, having high pH moved in suspended form and not as surface creep (in case of sand) except by the construction of large number of silt detention dams which made the soil to settle down in these water bodies. There was no way to arrest sediment flow in such characteristic type of soils having high silt + clay (35% silt and 40% clay) and high pH(9.6) except to tap the water carrying the silt in silt detention dams. This was still the more necessary when drastic reduction in silt load was needed as Lake was left with very limited capacity to hold water. This package brought silt load from more than 140 to less the 5/t/ha/yr.
- The silt cannot be retained without retaining water in the catchment area. We need water for the lake but not the silt. It was not possible to capture heavy laden runoff without these 180 silt detention dams. The masonry check dams have limited sediment retention capacity as compared to earthen silt detention dams. The de-siltation of these dams was also necessary to maintain their sediment retention capacity. However, in case of emergency, the water stored behind earthen dams can be drained to augment the capacity of the lake.

- Out of eight set objectives of the study, seven have been achieved to a large extent except the one on the impact of catchment storage of runoff on ground water recharge in adjoining area of UT Punjab and Haryana. This is well known fact that when large number of tube wells and bore wells start pumping lot of ground water in immediate lower areas, the impact of surface water storage in upper watershed becomes difficult to capture. This was also the conclusion of Kandi and Aravali projects.
- The following recommendations are made for future management of the system-
    - A system of silt control has been put in place by intensive efforts and spending lot of energy and resources. This has to be constantly maintained and monitored with scientific and technical inputs. The maintenance of the structures, management of vegetation cover complex for the benefit of plants and wildlife, protection against forest fires should continue to remain part of the dynamic management regime.
    - Limited manipulation of the bush cover like removal of *Lantana* from safer slopes to promote growth of palatable grasses for wild life may be continued as this is not going to cause any soil erosion.
    - The vertical cliffs would continue to trigger the problem of landslides and slided material has to be stabilised with location specific treatment package. Vegetative measures would be more appropriate in such a case.
    - The limited flow of water in drainage lines also act as fire line. The continuous presence of water in main drainage system particularly during summer month must be maintained by removing congestion wherever it occurs.
    - In case of any emergent situation, part of stored water in relatively bigger reservoirs of earthen dams can be released to the lake.
    - The drainage lines between the end of forest and the lake has to be well maintained so that sediment from non forest area does not travel to the lake.
    - The peripheral area of the lake has to be maintained in a natural wetland ecosystem without causing any disturbance.
    - Proper understanding of the ecological problem of deforestation caused by excessive grazing, illicit removal of trees, man-made forest fires and its consequences reflected in floods, siltation of reservoirs, loss of productivity and bio-diversity needs to be developed in the society taking the help of print and television media. The younger generations must understand the need of natural resources conservation and management for the survival of human race on the planet earth. Nearer home, Sukhna lake catchment presents a classical example of ecological recovery of a most degraded forest eco-system.