WATER LOGGING AND PROBLEMS OF SECONDARY SALINITY IN THE IGNP COMMAND AREA

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ABSTRACT

The expansion of brackishness and waterlogged condition in the Indira Gandhi Nahar Pariyojana (IGNP) operating region poses a significant challenge. Factors such as high temperatures, exaggerated aqua-miscible salts in the soil, and excessive desiccation-transpiration have led to secondary salinization and the accumulation of salts on the soil surface and in subsoil layers. The subsistence of impermeable stratum, coupled with the lack of superficial water evacuation outlets, has contributed to a rising water table, resulting in waterlogging. The persuasiveness of inundated cultivation in the IGNP region is at risk due to the progressive increase in soil salinity. Over time, the grieved land has metamorphosed unsuitable for cultivation. There is an urgent need for budget-efficient, enduring pacification initiatives and strategies to maintain fertility and caliber of soil in this inundated arid zone.

KEY WORDS: Indira Gandhi Nahar Pariyojana (IGNP), Irrigation, land salinity, Arid region

INTRODUCTION

Soil deterioration caused by salts and sodium ions is a critical challenge to the natural environment with significant negative effects on soil fecundity, cultivation and food guarantee, specifically in arid zones. In Indian context, approximately 8.4 m ha of land is impacted by salinization and alkalination, with around 5.5 million hectares suffering from waterlogging. Issues of waterlogging and salinization have been associated with irrigated agriculture since ancient times, including the civilization in Mesopotamia, whose decline is partly attributed to these problems. In arid zones, the risks linked to irrigation development extend beyond the commonly recognized secondary salinization, which includes waterlogged conditions and soil salinization. The mobilization of primary salts due to irrigation is an equally pressing concern, especially in the Indira Gandhi Canal operating region.

The Indira Gandhi Nahar Pariyojana (IGNP) is a monumental surface irrigation project located in the north-west and far west regions of Thar Desert, Rajasthan (India). As a unique and largest initiative globally, its primary goal is to convert desert wastelands into agriculturally productive areas. The project focuses on drought mitigation, providing drinking water, improving the environment, fostering animal husbandry, and boosting agricultural output. Initiated in 1963, the IGNP has been the main irrigation source for the regions it serves. It was designed to irrigate 1.79 million hectares of land across Rajasthan's districts, including Barmer, Bikaner, Hanumangarh, Ganganagar, Jaisalmer, Churu, Jodhpur. Over the past six decades, the framework of irrigation has metamorphosed the sterile desert landscapes to fertile and thriving agricultural meadows. However, intensive cultivation in the arid soils of the IGNP area has led to changes in soil properties, with salinity and waterlogging emerging as significant challenges.

THE STUDY AREA – GENERAL FEATURES

IGNP Stage-I: Stage-I encompasses the head reach of the Indira Gandhi Nahar Pariyojana project. It includes a feeder canal of 204 kilometers long, with the Harike Barrage in Punjab as the starting point, a 189 kilometers of long chief canal stretching from Masitawali head to Pugal head, and a 3,400 km distribution network. This stage is further divided into two phases:

- **Phase I:** Covers areas under canal irrigation originating from the starting till 74 km of the Main Canal.
- **Phase II:** Includes areas supplied by canals branching out from 74 km to 189 km of the chief canal.

The entire culturable command area (CCA) of Stage-I is 5.53 lakh hectares, which includes 61,000 hectares under the Kanwar Sain Lift Canal. This lift canal is included in Phase II and supplies drinking water and irrigation to the Bikaner district. The planned irrigation intensity for Stage-I is 110%. Major distribution networks in Stage-I incorporate the Naurangdesar, Rawatsar, Anupgarh, Pugal, and Suratgarh water courses (fig.1).

IGNP Stage-II: Stage-II comprises the lower reaches of the Indira Gandhi Nahar Pariyojana project. It includes 256 km lengthy chief canal extending from the end point of Stage-I at 189 km (Pugal Head) to its terminus near Mohangarh. This stage features an extensive distribution network of 5,780 km, covering a culturable command area (CCA) of 14.10 lakh hectares. Irrigation intensity is planned at 80% for flow systems and 60% for lift systems, with the lift area accounting for 5.37 lakh hectares of the command. The dominant bifurcated canals and water courses in Stage-II include Birsalpur, Dattor, Charanwala, Sagarmal Gopa, Gadra Road, and Nachna. The region ahead of the Sagarmal Gopa offshoot is under development.

How a rising water table affects salinity

The water table increases when more water infiltrates the soil than drains out. If the ground water level reaches more than 2 mts below the ground level, underground water can move upward through capillary action, bringing water to the surface. As this water evaporates, soluble minerals accumulate in the region of root. However, when the water table is deeper than 2 meters, the fluid tension typically do not affect the region of roots of most crops. Consequently, effective irrigation, out pouring, and land use planning strategies ought to aim at maintaining the water table right beneath 2 meters to prevent salty groundwater from reaching plant roots.

In the IGNP command area, approximately 0.208 m. hectares of area are formerly impacted by drenching and brininess. The affected soils are primarily found in regions served by the Anupgarh, Suratgarh, and Charanwala branches. The natural groundwater balance in the IGNP region has been disrupted, leading to waterlogging due to various factors, which are argued below.

Water leakage from multiple sources: The Central Water and Power Research Centre's report on IGNP identifies two primary causes of leakage from the chief water course. First, the bank walls of chief water course were constructed using a mixture of quarter to half proportion of silt and half to three quarter of fine to medium sand, materials with an elevated degree of hydraulic absorbency. Second, seepage may also result from damage to the canal's lining.

Naturally occuring drainage system absent: A key factor contributing to drenching in the IGNP region is the unavailability of an innate out pouring system. The area lacks functional rivers, making surface drainage virtually impossible.

Hard pan Present: The porous rock stratum system in the IGNP region currently consists of a complex structure of sand and clay layers, interspersed with clay, silt, and kankar lenses along with occasionally occurring rocky strata. This bed rock acts as aquatic obstacles, preventing percolated water from infiltrating to deeper levels. Combined with the lack of surface drainage outlets, the presence of these impervious layers is a significant factor contributing to the elevation of the aquatic level and the resulting drenching.

Causes related to Soil: The soil in the IGNP zone are part of expansive ancient floodplains combined with wind-blown deposits (sandy Aeolian deposits) from the Saraswati, Ghaggar, Sutlej, Chautang, and east bifurcations of the Indus river. These floodplain topsoils are deeply graduated, calcified, and often affiliated with brininess and basicity issues. Wind-blown soils (Aeolian soils) overlay the floodplains and extend across the region with moderate to elevated dunes. In the inter-dunal plains, subsoils occasionally contain kankar or gypsiferous layers, sometimes found in the range of 1.5 meters of the top soil.

Excessive water allocation: Over-application of water, especially in the course of introductory periods when the dominion region was still under development, along with consistently intensive irrigation practices, has been a major contributor to waterlogging. It is now evident that during the early stages, the amount of water supplied significantly exceeded the actual needs of the area.

Downward flow of water from higher to lower areas: The design of the IGNP takes into account the region's topography, allowing water to flow naturally from higher-altitude areas to lower-lying regions without the use of lift systems along the main canal and feeder. This design directs all surface water downhill. Probably, it is seen that high elevation zones will become saturated with water due to hydrostatic constraint, the infiltrated subsurface water may also move downward. Such inclination flux of percolated water has been observed, particularly starting at loftier regions of Hanumangarh and Suratgarh to subsided areas.

Developing soil salinity secondarily: Secondary salinization of soil typically occurs in irrigated regions with substandard water and inadequate tillage and water conservation. Factors such as improper irrigation practices, low-quality water, poor out flux, and inefficient crop husbandry and land utilization contribute significantly to this issue. While the hydrological processes driving mineral movement in both natural and anthropogenic salinity are analogous, the key polarity lies in the management strategies available to mitigate secondary salinity. The wearing away of mantle rock is the principal origin of minerals found in canal water. In barren lands, higher evaporation rates result in a steady increase in salt proportion within water courses and the soil profile. This highlights the strong influence of localized atmospheric conditions on soil salinization. As the rate of vaporization exceed water percolation, it favours accumulation of sodium minerals superficially because of upward movement driven by plant transpiration and evaporation from the phreatic aquifer. Thus, excessive vaporization stays the primary cause influencing the potent salinity conditions in these parched areas.

Movement of Salts: Extensive agricultural water infrastructure improvement in parched regions practically unavoidably triggers the movement of significant quantities of natural salts stored in the surrounding lands or deeper subsurface layers. Various mechanisms contribute to this salt mobilization, as illustrated in the figure. Leakage and seepage commonly transport salts from elevated areas to bottom regions. Salt movement to the soil surface primarily results from upward water flow driven by evapotranspiration (convection) and from salinity gradients with depth (diffusion). Soil texture and the stratification of layers with varying textures significantly influence the patterns of salt migration. Additionally, the existence of impermeable blankets, coupled with the lack of superficial discharge outlets, plays a critical role in the rising of artesian basin and successive drenching in low-lying and swampy areas.

Reclaiming the salt affected drenched soils

Superficial and subterraneous drainage: An effective drainage system is essential for preventing or resolving waterlogging and salinity issues. In many cases, natural drainage combined with proper water management can effectively remove excess water, reducing the need for costly subsurface drainage systems. However, farmers using surface irrigation should ensure the availability of ample superficial discharge to handle surplus water. Subterraneous discharge can be achieved by constructing open trenches or installing buried systems, such as clay or concrete tiles or perforated pipes. Designing Subterraneous discharge is typically too intricate as compared to superficial drainage systems and needs a solid understanding of subterranean hydrodynamics.

Agroforestry: Certain species of grass possess mechanisms to withstand elevated salt concentrations in the rhizosphere. Such salt-forbearing grasses can either limit the uptake of salts from the soil or the accumulation of relocated salts in specific parts of the plant, preventing interference with metabolic activities. One such species is *Brachiaria mutica*, which thrives even under prolonged waterlogged and saline conditions. Studies have also explored the presentation of these grasses when combined with salt- forbearing trees like *Acacia nilotica* and *Prosopis juliflora* in integrated diversified farming system. Notably, *Leptochloa* grass exhibits a unique trait of disappearing as soil sodicity levels decline.

Biodrainage: This method involves reducing groundwater levels in waterlogged areas by planting trees. The trees eliminate surplus soil moisture by means of transpiration, utilizing solar energy in the process. It serves as a preventative measure to curb the onset of brininess and water drenching in waterway command areas. The methodology is particularly effective in areas where salinization is in its early stages due to rising groundwater levels. However, its effectiveness is limited in soils that are already heavily salinized. Prominent tree species recognized for bio-drainage include *Casuarina*, *Eucalyptus*, *Bambusa* and *Populus*. Numerous initiatives are underway across the nation to retrieve water drenched regions in waterway command regions using this approach.

Aqua depuration and Soil improvement: Soil amendments and aqua depuration frequently provide a pragmatic and cost-effective solution for addressing issues commonly associated with brackish and sodium rich soils. As evaporation from the water table causes salts to accumulate superficially, fracturing the hydrostatic connection of surface-tension driven upflow by re-establishing vegetation on derelict land before and during torrential rains can help reclaim saline soils. Following this approach, downpour facilitate percolation, whereas agriculture disrupts the capillary flow. Generally, water applications are aimed at altering the chemical properties of irrigation water to prevent farther deterioration of fertile soil. Modification of soils are applied for both the elementary retrieval and the life-long conservation of soil health. Gypsum and elementary sulfur are commonly utilized to reclaim sodium-rich soils.

Administration of Fertilizers: Many fertilizers enclose high concentrations of dispersible minerals, making the means of nourishment, application pace, regularity, and positioning, crucial factors in crop yield. Mineral index has been reported for maximum mercantile fertilizers; for instance, Potassium Chloride has 205 times elevated salt index as compared to K_2SO_4. It is typically recommended to avoid applying those fertilizers which have higher salt indices particularly near the seedlings, especially in band applications. The salt content of other soil additives, for instance gypsum and organic manure, should be taken well into account. Application of gypsum is an effective administrative exercise to prevent sodium buildup in the reciprocal platform of soil and helps in maintaining its structure, and boost water percolation. Gypsum should be applied far in advance of sowing to prevent dispersible salts from negatively affecting crop growth, for salt-responsive plants like lettuce.

SUMMARY

The imperishability of agriculture in the IGNP dominion region is increasingly jeopardized by rising soil salinity. Water drenching and superficial pooling have disrupted the innate wetland ecosystem and led to the development of saline soils. Over time, this has rendered the affected land unsuitable for agricultural use. The growing brininess in the lowlands of the IGNP area is primarily due to unsustainable agriculture exercises, poor irrigational quality of water, absence of revolutionary irrigation techniques and competent out-flux systems, and inappropriate land administration. Enrichment of soil by fertilizers and irrigational exercises should be based on well-established guidelines that take into account the local soil and climatic circumstances and plant needs. There is an urgent need for cost-effective, long-term mitigation strategies to preserve soil fecundity and standards in this irrigated barren province.

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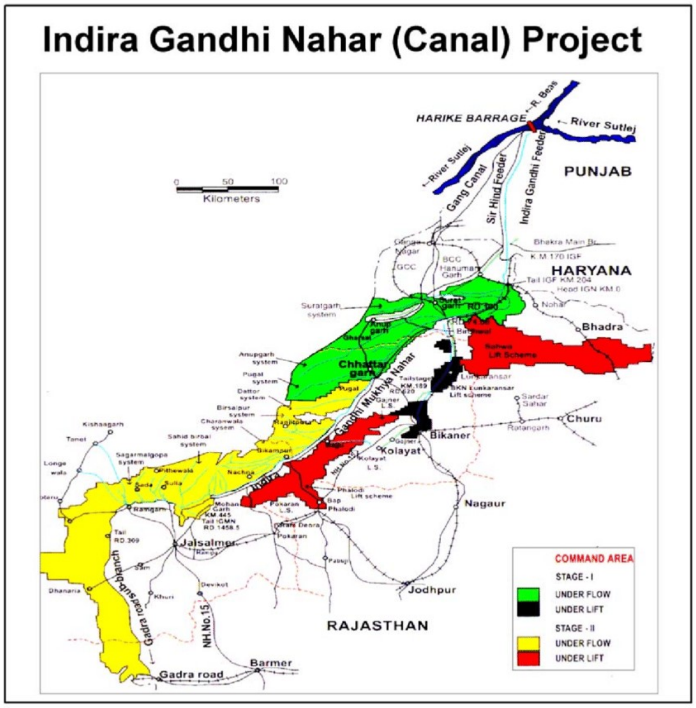

Fig 1: Indra Gandhi Nahar Pariyojna (Rajasthan)