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ECOLOGICAL STUDIES ON LUNI RIVER BASIN

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ABSTRACT

Since the prehistoric time the river banks are the centers for large settlements. The whole Indus valley civilization flourished on the bank of the Indus, the Ganges and their numerous tributaries. The tradition still continues, the most of the large cities are situated on river banks. Rivers provide water to sustain domestic supply and industrial consumption. It has been estimated that the quantity of water consumed is only 20% of the total water used. Rest 80% emerges with all the pollutants in it and termed as sewage or effluent as per the origin. The situation in arid zone of India, especially in western Rajasthan, is really grave where water scarcity is the normal phenomenon and people are dependent mainly on monsoon. The river catchment of Luni, a monsoon flowing river, is full of industrial drainage along with other wastes. The land of the catchment is losing its potentiality day by day and the monsoon water flowing through it carrying harmful waste is the main drinking water of several small villages. This water is the carrier of several diseases and thereby causing illness of the poor villagers. A review on industrial pollution in Luni river and efforts to combat this is presented in this paper as review.

INTRODUCTION

The people of arid and semi-arid zones live on the margins of scarcity. A crisis is not impending rather crises have been recurrent. In western Rajasthan, a part of Indian arid zone, there is acute shortage of good quality water for drinking and irrigation. The rivers of Rajasthan except for the Chambal are ephemeral and flow only during rainy season. The river catchment areas, which are largely influenced by local topography and amount of precipitation, very largely showing an indelible impact upon the drainage system. In the absence of any formidable mountain barrier in the State and the low quantum of annual rainfall, the river catchment areas are mostly small. The flat, rugged and undulating rolling lands of the low hill and plateaus, which are the origins of the rivers and streams, are highly dissected and devoid of deep channels to add stream density.

Luni is the only major stream on west of the Aravalli ranges, which meets the sea in the Rann of Kutch. It originates in Nag Pahar in Ajmer and flows southwest through Jodhpur, Barmer and Jalore over a distance of about 320 km covering a total catchment area of 37,363 km. Its catchment area has spread over some parts of Nagaur district also. It flows only during the rainy season and even at this time the river is choked with advancing sands at many places. Even in the monsoon months when the water flow rate is high and at its peak, the flowing water is not able to cut these sand deposits on the river bed, and as a result of which the runoff spreads to the adjoining fields on both the banks of the river braiding it. This results in sand deposition on arable and non-arable lands, thus, adversely affecting their productivity.

LUNI BASIN

Luni river basin is located in southwestern Rajasthan between latitude 23°4’ and 27°5’ and longitudes 71°4’ and 74°42’. It is bounded by the arid western districts (the outside basins) in the west, by Banas basin in the east, Shekhawati basin in the north and Sukli and west Banas basins in the south. The basin extends over parts of Ajmer, Barmer, Jalore, Jodhpur, Nagaur, Pali, Rajsamand, Sirohi and Udaipur districts.

Luni river basin lies to the west of the Aravalli hills and forms part of the midwest alluvial plain. Orographically, the eastern part of the basin is marked by hilly terraces belonging to the Aravalli chain and west of the hills lies in a narrow alluvial plain that gently slopes westwards. Luni river originates in Ajmer and flows to the Rann of Kutch in Gujarat State. Its total cultivable area is 1.42 million ha and total culturable command area is 248706 ha. By the use of Luni river water several projects, in nearly 164617 ha area, exist and proposal for another 8415 ha is under consideration.

The water of River Luni is sweet up to Balotra and becomes more and more saline further downstream. The main tributaries of Luni on the left are Sukri, Mithri, Bandi, Khari, Jawai, Guhiya and Sagi, whereas only Jojri river joins it on the right side. The mean annual rainfall over the Luni basin is normally 320 mm of which nearly 95% falls between July and September. By the Luni river water four irrigation projects are under construction and 25 more projects are proposed.

SOIL AND LAND CAPABILITY

In the Luni basin nearly 30 series of soils, based on soil taxonomy are present. The soil type range from fine textured soils (soil with clay, silt-clay or heavy clay-loam in subsoil), moderately fine textured soils (soil having clay-loam, silty clay-loam, sandy clay-loam in subsoil), medium textured soil (soil having sandy loam, loam, silty loam texture in subsoil) and coarse textured soils (soil having sand, loamy sand and gravel in the subsoil). Inadequate moisture in soils is the major limiting factor for crop production in the basin. In major parts of the basin, the ground water is of poor quality. The probability of occurrence of drought is also substantially high. Due to these constraints the land of Luni river is not of the best quality and, therefore, not much productive. However, there are certain areas along river banks where reasonably good quality water is available at comparatively shallow depth where double cropping is practiced. The majority of land is suitable for rainfed cropping. In the fine textured soil jowar, maize and gram are the major crops. In moderately fine textured soil wheat, rayada, rijika and barley etc. are grown. In medium textured soil bajra, til, mung, guar etc. whereas in coarse textured soil bajra, guar, moth, mung etc. are the major crops grown.

PLANT RESOURCES

In the Luni river basin the major tree species found are *Anogeissus pendula, Boswellia serrata, Acacia leucophloea, Acacia senegal, Acacia catechu, Acacia nilotica, Salvadora persica, Zizyphus nummularia, Prosopis cineraria,* and *Maytenus emerginata* etc. Besides these, several shrub species also exist namely *Grewia tenax, Capparis deciduas, Rhus mysorensis, Euphorbia caducifolia* etc. and *Prosopis juliflora.* These plants have not only fodder value but also used for fuel wood fruit and medicinal value too.

WATER RESOURCES

Water requirement for crop is normally met with from ground water storage or from storage reservoir in this region. There are two major (Sardar Samand and Jawai dam), nine medium and 344 minor irrigation projects in the Luni river basin as well as some small irrigation systems (covering less than 20 ha constructed and operated by Panchayat Samities). Besides these, 2514 ha will be irrigated by completion of four irrigation projects and an additional area of 8399 ha is planed by proposed 25 irrigation projects.

Most of the water requirement for irrigation, drinking and industrial purposes within the basin is met with from ground water. As a result, water level depletion is recorded in major parts of the area.

The ground water in Luni catchments is generally freshwater, but in Jojri and part of Guhiya and Bandi catchment it is saline. The bicarbonate type of characteristics is noticed in low salinity ground water in Luni catchments. They are mostly associated with alkaline earths. The associated cations are either sodium or alkaline earth.

A study carried out by CAZRI (Jodhpur) between 1984-92 indicates that there have been significant changes in agriculture, industrial development and urban expansion. All these factors have considerably influenced the ground water regime, especially in Pali district. Reports indicate that the ground water resources in most of the zones of Luni are under stress due to overexploitation. The stage of ground water development in crystalline is low but scope for construction of additional wells is very limited due to poor storage capacity of aquifers. The part of Pali and Jodhpur districts are affected by chemical pollution due to effluent from textiles and other industries and leaching from chemical fertilizers. The overdraft conditions and deteriorating chemical quality of ground water need attention. The conservation of water resources and augmentation through recharge by artificial methods utilizing rainwater is needed. Small rain water harvesting structures such as surface barrier and percolation tanks constructed at suitable sites would help in recharging the ground water. The adoption of modern methods of agriculture such as dry farming, mixed cropping and agro-forestry with drip irrigation and other techniques would promote water conservation. The parts of Pali and Jodhpur districts, affected by chemical pollution, require immediate corrective measures.

WATER LEVEL FLUCTUATION

Water level fluctuates in response to local recharge/draft condition. A fraction of rainfall infiltrates and joins the ground water, resulting in rise of water levels. Variation in infiltration rate in the vadose zone and specific field of aquifer causes wide range of water level fluctuations. As a result of excessive use of ground water, water level depletion is recorded in major parts of the area. The water level two decades ago, before industries entered the Luni basin, was 15-40 metres below ground level (mbgl), which went up in 1997 up to 3-5 mbgl, due to good rainy season. In fact, it is still below what it was two decades ago but it is fluctuating depending on the area and climatic condition of the river catchment area. The scarcity of water in summer may lead to water crisis and the high rate of water tankers.

LAND USE

In the Luni basin a detailed study on the upper Luni basin which include Pali in south, Borunda in the north and Jodhpur and Samdari in the west, indicates that cultivated land covers nearly 66.88% (out of which 90% is rainfed), wastelands 15.27%, pasture 6.61% and forest 6.41%. Due to rainfed land the crop production varies depending on the rain. Cultivable land was significant in the past. The land use in Luni basin is subjected to many limitations and susceptible to natural hazards and as such each parcel of land should be properly and cautiously utilized with suitable management practices.

AGRICULTURE AND AGRICULTURAL PRODUCTION

In the Luni basin nearly 66.89% of the total area is used as agricultural land and 73.5% of the total population subsists on agriculture. Out of the total cultivated land 84% is put to rainfed agriculture. The annual cropped area, cropping pattern and yield are governed by changing pattern of soil texture and depth, slope surface and ground water potential, severity of natural hazards, rainfall and other climatic parameters as well as socioeconomic conditions of the people. The main crops of the basin are cereals, oilseeds, pulses and others. Cereals are nearly 49% and include bajra (29%) Jawar (11%), maize (2.5%), wheat (6%) and barley (0,64 %) in different regions and their yield vary considerably. Oilseed crops which are nearly (25%) include sesamum (13.6%) and mustard (10.11%) along with other crops like groundnut, taramira, castor and linseed with different yields in different parts. Pulses constitute about 10% of the total area and include moong, moth, cowpea and gram. Besides these, several other cash crops like cotton, chilli, methi and cumin are also produced in nearly 1.3% of the total area (Gupta 1995a,b, Singh & Balakram 1997).

MORPHODYNAMIC PROCESSES AND ASSOCIATED HAZARDS

A land reform of Luni basin is formed by both fluvial and aeolian processes that at many places beneficial but at several places creating problems. It has been calculated that 55.12% of the total basin area is affected by fluvial crossional hazards. Among the other hazards aeolian depositional hazards cover only 1.33% area, salinity alkalinity covers 9.21% area and different combinations of all these three principal hazard types cover 3.86% area. Thus, 69.60% area of the basin is affected by different hazards leaving only 30.4% area free from them. In the Luni river basin the drought years were 1958, 1961, 1963, 1964, 1967, 1968, 1969, 1971, 1972, 1974, 1977, 1978 and 1979 whereas flood years were 1980, 1986, 1987, 1988 and 1993 (Shankarnarayan & Amalkar 1994).

SURFACE WATER DEVELOPMENT

Though numerous streams collect surface water normally to be used for human and livestock consumption, the actual situation is far from satisfactory. Nature is not only or alone to be blamed for the vagaries, however, human follies like construction of some reservoirs at places, where it is favoring salinity, has also added to the problem like Kharda lake on Jalore granite terrain. Therefore, for any rational planning of the water resources of the basin, both natural and man induced factors are to be kept in mind.

In order to conserve the surface water there is need to renovate the village rivers, construction of water storage structures and of small underground water reservoir (tanks) etc. Besides these, there is also a need for better management of this scarce commodity in its existing setup. Since interaction with other environmental parameters play important roles in the mutual benefit or otherwise to the interacting processes, the management of the surface water of the basin should also entail those environmental factors.

GROUND WATER DEVELOPMENT

Due to low ground water recharge capacity the basin area has very low ground water level. In its catchments the groundwaters have EC values ranging from 2000 to 8000 micromhos. Owing to these conditions it is recommended that too much tapping of the ground water should be stopped and there should be efficient distribution and management of ground water resources. Although ground water with 8000 µmho EC may be used for irrigation in sandy soil but it is suggested that such water with gypsum should be used to nullify any adverse effect (Shankarnarayan & Amalkar 1994).

INDUSTRIES AT PALI AND JODHPUR AND THEIR EFFLUENTS

There are large numbers of small scale textile processing units in Pali district, and nearly 250 units of different types are working in Jodhpur. Rainwater harvesting is the only source of raw water in River Bandi and other water bodies. River Bandi remains dry throughout the year. The ground water is

Table 1: Chemical composition of textile effluent at Jodhpur.

Effluent parameters	Range	Mean
Optical density (OD)	0.08-0.40	0.28
pH	8.82-11.8	9.7
EC(dSm^{-1})	3.82-10.7	5
Total solids (g/L)	3.42-19.3	7.5
TDS (g/L)	3.12.-18.8	6.5
Residual sodium carbonate (mg/L)	12-125	41
Sodium adsorption ratio (SAR)	30-153	128
Phenolphthalein alkalinity (mg/L as $CaCO_3$)	49-5200	1025
Total alkalinity (mg/L as $CaCO_3$)	560-6200	1535
Chemical oxygen demand (mg/L)	160-800	377
Ionic composition :		
Sodium (mg/L)	600-5500	2069
Potassium (mg/L)	25-30	38
Calcium (mg/L)	Traces-30	10.2
Magnesium (mg/L)	Traces-8	4
Copper (mg/L)	Traces	Traces
Zinc (mg/L)	Traces	Traces
Cobalt (mg/L)	Traces	Traces
Iron (mg/L)	Traces-0.67	0.35
Carbonate (mg/L)	29-278	86
Bicarbonate (mg/L)	280-1136	592
Chloride (mg/L)	410-806	680

Source: Singh et al. (2001).

Table 2: Textile industries and their characteristics at Pali. Source: Singh et al. (1995).

Characters	Range
pH	7.7 to 10.8
EC(dSm^{-1})	4.4 to 16.3
Colour	Light to dark green; reddish and purple
Activity of industries	Desizing, bleaching, mercerizing, dyeing and printing etc.
No. of textiles industries	700 (small to big units)
Discharge of textile effluent (Industrial wastewater)	4 million gallons/day
Effluent contaminants	Chemicals, dyes, caustic, oils, detergents, etc.
Effect of industrial effluent	Water resources, agricultural land, seasonal river, health, fauna and flora of the region.

Table 3: Soil characteristics of industrial wastewater irrigated experimental field at Jodhpur.

Tree species	Soil sample	pH 1:2		EC 1:2 (dSm^{-1})		SAR	
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Colophospermum mospane	I	8.4	7.6	0.19	1.13	1.17	3.70
	II	9.1	7.8	3.70	4.11	8.75	17.30
Eucalyptus camaldulensis	I	7.8	7.8	0.88	0.94	2.83	4.17
	II	-	8.5	-	0.70	-	3.27
Acacia nilotica	I	7.4	8.2	1.13	0.29	4.00	2.50
	II	8.3	8.3	4.11	0.90	6.79	2.83

I = Initial; II= Four months after effluent irrigation of water in River Jojri. Source: Singh et al. (2001).

being used for industrial purposes heavily. The treated effluent from CETP along with city sewage is discharged in Bandi river. Bandi river joins River Jojri at upstream Jodhpur which joins Luni.

River Jojri and Kaylana lake are the two important surface water bodies in Jodhpur. The freshwater in River Jojri flows only in upstream reach at Kurigaon as a result of rainwater harvesting during monsoon. Downstream of this location, the river remains dry throughout the year and no freshwater except the domestic and industrial wastewater of Jodhpur flows in the downstream.

Mostly textile and pickling industrial waste water is discharged from various industrial areas such as Jodhpur industrial area, Basni industrial area (Phase I & II), and heavy industrial area and light industrial area behind power house. The River Jojri joins Luni at downstream during monsoon. The main environmental problems for restoring the water quality of Bandi and Jojri rivers are maintenance of minimum flow of freshwater in the downstream stretches of the rivers and discharge of industrial and domestic wastewaters in them.

Pali case study

This city has several textile processing units located in various industrial complexes. There are more than 767 small scale industrial units along with a very large textile industry manufacturing cotton and synthetic yarn and fabrics Maharaja Shree Ummaid Mills Ltd. The total water requirement of Pali industrial area is about 42 MLD which is fulfilled by underground water and from Municipal Corporation supplies water, which is mainly rain or canal water. The entire untreated polluted wastewater generated from textile processing units from various industrial areas is discharged into the River Bandi through various drains. Thus, the River Bandi takes up the entire pollution load of the city. The River flows along the side of the city. The Bandi river is dry except for few days in monsoon period and only industrial wastewaters are flowing mostly throughout the year. Its pollution impact is observed up to 40 km downstream of the river. The CETP, Pali report indicates that nearly 30 MLD wastewater is discharged into drains, generated from the industrial areas, besides 5 MLD wastewater from Mandia Road industrial Area-Phase III, presently being treated at existing CETP.

Textile Processing and Wastewater Generation: In the process of cotton textile manufacturing, after kiering the cloth, it is subjected to the bleaching operation to remove the colouring matter from cloth so as to tender the fabric for the subsequent dyeing operations. For this the cloth is steeped in a cold solution of sodium hypochlorite and chlorine, squeezed between the rollers and exposed to the air. The operation requires large quantity of water, and wastewater from bleaching contains spent bleach liquor, alkalinity, solids and some organic matter. After the bleaching, mercerising or causticizing is done and then dyeing and printing. In printing of Khaddi and Prussian type, again large amount of water is used.

Treatment Plant: With the help of NEERI and Pali Water Pollution Control Board, a treatment plant of 1 MGD is working and two more are in progress with 1.5 MGD (unit 2) and 2.0 MGD (unit 3). By this, 4.5 MGD polluted water can be treated. The unit 1 is increased by 0.5 MGD therefore, total 5.0 MGD is the maximum capacity of these treatment plants which is still very less in comparison to the industrial wastewaters generated.

Cost of the Treatment: There is general support throughout the world for the ”Polluter Pays Principle” i.e., industry must pay the cost of disposing waste in an environmentally acceptable manner. It follows that the cost of operating a CETP must be borne by the industry. Even if sludges and possibly the final effluent could be utilized it would result in the reduction of total expenses.

Use of industrial effluent: In Pali, more than 700 small and large scale units are discharging nearly 40-50 million gallons/day of industrial effluents into nearby agricultural lands and drinking water resources including seasonal river basin areas. The chemical composition of textile effluent shows the presence of coloured dyes, high pH (7.7- 10.8), EC (4.4 - 16.3 dSm^{-1}) having predominance of sodium content of 2736 ppm and near absence of calcium and magnesium. Manganese, copper, iron and zinc are present in agreeable amount with traces of cobalt and cadmium. Such industrial effluent can, thus, possibly be utilized for establishment of certain economic tree species of this region and soil deterioration can be reduced by some soil amendment. A study by CAZRI (Singh et al. 1995) shows that industrial effluent is of high saline quality and it can also be utilized for afforestation with some soil treatments in arid zone. The *Colophospermum mopane* (fuel and fodder tree), *Eucalyptus camaldulensis* (timber and fuel wood tree) and *Acacia nilotica* (fodder, fuel and timber tree) was used in the study, which performed satisfactory. As per reports, 9-17 tonnes of gypsum per ha can be applied to reduce sodicity. Beside this salt tolerant crops and vegetation could reclaim degraded land (Singh & Balakram 1997).

Jodhpur case study

In Jodhpur, textile and chemical industries are nearly 300-400 in different industrial areas. Their effluent has high pH, electrical conductivity (EC), sodium absorption ratio (SAR), and residual sodium carbonate (RSC), whereas the bivalent cations are in traces. The study carried out by Arid Forest Research Institute, Jodhpur (Singh et al. 2001) indicates that wood ash treated with soil irrigated with effluent could be used to attain good plant biomass. These studies suggest that the industrial effluents in Jodhpur, which are also released in river basin catchment areas, could be used for plantation purpose. Everyday tons of wastewater containing harmful chemicals is flowing into the river catchment area thereby polluting them.

Ground water and its contamination: Many areas of ground water and surface water are now contaminated with heavy metals, POP (persistent organic pollutants) and nutrients that have an adverse effect on health. Waterborne diseases and water caused health problems are mostly due to inadequate and incompetent management of the water resources.

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