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Ecology of River Corridors in India with Special Reference to Soil Conservation and Pollution

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Abstract This paper summarises our findings on the vegetation, biotic pressures, and habitat features of the riparian corridor slopes of river Ganga, its tributaries Gomati and Varuna and sub-tributaries Rihand and Chandraprabha around Varanasi. Habitat stability and soil fertility are delicately balanced mostly by the self-grown cover of herbaceous and shrubby vegetation which are encountering intense biotic pressure of grazing, garbage removal, crop cultivation, discharge of city sewage mixed with effluents from numerous cottage industries in Varanasi and heavy industries in Obra-Renukoot region drained by the Rihand River.

It is found that under natural heavy rain the conservation value of a few grasses and dicot weeds are high (85-95%) under protection, as compared to bare condition. Variation on account of antecedent soil moisture, simulated rainfall intensity in soil erosion, water runoff and nutrient flow down into the main stream are recorded. Iron and chloride are far in excess in industrial belt effluents while at Varanasi the Ganga receives heavy load of municipal raw sewage, chemicals and ash-loads from the burning of dead bodies.

Key words : River corridors, soil conservation, pollution.

Rivers are natural bodies of flowing water formed during recent geological times as a result of physical process of conversion of rainfall and melting snow into streamflow of water down the gradient and convergence and merger of several streams into a main water course. Rivers perform the principal function of balancing the annual hydrological between the land-sea exchanges. Human kind have settled, thrived and culturally evolved on the banks of rivers since time immemorial. River banks have been favoured as nucleus of rural and urban growth due to easy and perennial supply of life supporting drinking water, domestic and live stock water needs, bathing and swimming, irrigation and industrial water supply, easy agricultural operation on riparian banks and flood plains requiring least inputs, fish supply, and easy riverway transport connections between cities and trade centres and sea ports. The main part of our research activities are around River Ganga at Varanasi and its tributaries in North India. Varanasi is probably the oldest living city situated on the banks of River Ganga. It has been the seat of education and culture and fountainhead of oriental religions and Lord Budha chose this city, already then at peak of scholastic activities to deliver his first sermon after enlightenment.

Indian rivers are principally divisible into two categories: first originating in the snow covered lofty but young mountains of the Himalayas and flowing down to south initially and then taking either an eastward course to sea like the Brahmputra, Ganga and the tributaries Yamuna, Ramganga, Gomati, Kosi and Gandak etc. or to the west like Sutlej, Jhelum, Ravi, Chenab, Beas rivers forming the mighty Indus river. The other category of rivers originate in the mountains of the peninsular Central and South India and draining down either to the west in Arabian sea or to the east in the Bay of Bengal. River Sone, however, originating in the northern slope of Vindhyan Hills flows to north easterly direction of the Uttar Pradesh and Bihar states and joins Ganga. Most of these rivers are in a highly polluted state. Numerous important cities are located on the banks of these rivers.

River corridors comprise the (i) central perennial water flowing zone, (ii) the periodically exposed marginal riparian slopes and (iii) the flood plains.

In recent years due to the phenomenal increase of human population in India, the vegetal cover in the water sheds and along the riparian uplands has been severely degraded and depauperated. Agricultural operations, establishment of industries and growth of cities have extended to almost up to the edge of river corridors leaving no space any more for the buffer vegetation zone. The ecotone between the terrestrial uplands and river

water course naturally provides an excellent fertile, longitudinal tract which acts as a filter for withholding excessive inflow of soil, organic debris, dissolved nutrients, pesticides, herbicides, industrial wastes, village and town sewerage, etc. Riparian ecosystems, experiencing pulse of floods followed by exposure, deposition of silt, etc., are rather delicately balanced and ecologically fragile. Different anthropogenic pressures disrupt the ecological balance and result into formation of ups and downs, gullies, ravines and gorges. They also change the physico-chemical characterization of water and at frequent intervals of space pollute the river differently at some places with toxic heavy metals, with other chemicals, with disease causing pathogenic microbes, or with intense biological magnification of pesticides, etc. Further due to almost doubling of the runoff water from the degraded watersheds and several fold increase in the silt load due to accelerated erosion, river beds are getting raised up and floods are becoming more frequent and devastating.

In this paper besides a general account of Indian rivers, special attention is given to the river Ganga, and its tributary, Gomati and subtributaries Rihand and Chandraprabha. The nature of anthropogenic pressures, the extent of erosion, the conservation potential of different riparian plant species and the nature and extent of pollution are given.

Nature and extent of anthropogenic pressure including pollution

It is estimated that the present population of India is about 850 million of which about 20% live in the urban areas and 80% in the rural areas. River Ganga and its tributaries extending over a large segment of north Indian plains sustain 200 million people and as such the river ecosystem are under very severe anthropogenic pressures including pollution. Major cities with extensive discharge of industrial effluents and sewage located on the banks of Ganga are Hardwar (antibiotics industry), Aligarh (power plants and metal works), Kanpur (cotton and woolen mills, leather tanneries), Allahabad (confluence with River Yamuna), Mirzapur (metal works, chemical factories and thermal power houses), Varanasi (confluence with Varuna, paper mill, chemicals and fertilizers, locomotive engines, cotton, silk and woolen cottage industries, metal works), Ghazipur (confluence with River Gomati, opium factory), Patna (confluence with River Sone), Barauni (oil refinery, distillery, shoe factory, thermal power station and fertilizer factory), Bhagalpur, Howrah and Calcutta (densest concentration of human population, with hundreds of industries), on the banks of the River Yamuna (a tributary of River Ganga) are located the cities of Delhi (powerhouses and numerous industries), Mathura (oil refinery), Agra (leather, iron and steel industries). The other major tributaries are (1) Gomati with state capital city Lucknow and the ancient city of Jaunpur with numerous cottage industries, (2) River Sone draining the heavily industrialized area of southeast U.P. and southwest of Bihar states, polluted by super thermal power houses, aluminium industry, chemicals, cement, paper and sugar, etc. It joins River Ganga at Patna, (3) Damodar river, also a tributary, drains through the south Bihar belt of extensive coal mines, thermal power plants, steels and fertilizer factories. Other tributaries of Ganga are Kosi and Gandak in North Bihar. The river system of central and south India are Godawari and Bhadra river in Andhra Pradesh polluted by thermal power plants and poly fibres industries. River Cauvary in Tamil Nadu is also heavily polluted by chemical factories, leather industry, etc. River Periyar in Kerala is under the stress of heavy pollution load from chemical, metallurgical, rayon and possibly radioactive wastes from several industries. The other heavily polluted rivers are Kalu in Maharashtra, Rushikulya in Orissa and Narmada in Madhya Pradesh.

Now we shall concentrate on the case studies at Varanasi and neighbouring areas. Ambasht and Tripathi (1985) have compiled a series of papers on these aspects. About 3000 very small to medium sized industries dealing with food processing, weaving and dyeing of cotton and silk clothes and woolen carpets, wooden toys and furniture, leathers processing and shoes, printing, chemicals and fertilizers, metal works, electrical goods including fans, pumps and motors. There are some large industries also such as diesel locomotive engines works. In most of the small scale industries the toxic effluents join the municipal sewerage system and reach the river at Rajghat

sewer discharge point (Fig. 1). About 25 million gallons of sewerage per day are discharged here which may have a high BOD of 180 to 600 mg/1. More than 30,000 dead human bodies are cremated using about 15,000 tons of wood every year on the two burning ghats located at the southern upstream and northern part of the city. This is responsible for (i) huge quantity of ash of burnt woods and dead bodies, (ii) rise in temperature and cremation of thermal blocks to migratory fishes, (iii) reduced dissolved oxygen levels, and (iv) an unaesthetic site of vultures and dogs clamouring over the floating and unburnt portions of dead bodies. The next most important source of pullution is the mass scale washing of clothes on the Ganga bank. The practice of washerman collecting dirty clothes from house to house and taking them to the river bank for washing exists throughout in the country. Washermen mostly use alkali earth (Reh), and sometimes soaps and detergents. This adds to change in pH towards alkaline side, enrichment of phosphates and eutrophication. The other major anthropogenic stresses are (i) the bathing rituals joined by tens of thousands of pilgrims, (ii) removal of sand for house construction purposes amounting to thousands of trucks every year, (iii) extensive destruction to natural vegetation, (iv) cultivation of riparian slopes (Fig. 2) (runoff of pesticides and fertilizers). It is a common site to find hundreds of buffalows (Fig. 3) bathing and being washed on ghats (specific points on the river bank) set aside for them. The government of India, realizing the magnitude of pollution of the river have taken massive steps to divert the municipal sewage to treatment tanks and reduce open air cremation by the construction of one electric crematorium at Varanasi. However, much more needs to be done as even now there is extensive sewer discharge and continuous open air cremation of dead bodies round the clock.

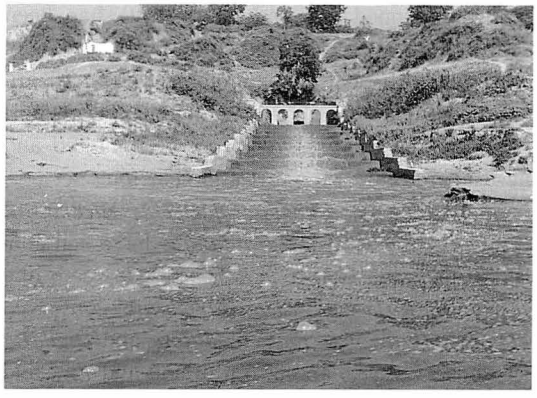

Fig. 1. Photograph of main sewar discharge at Rajghat, Varanasi.

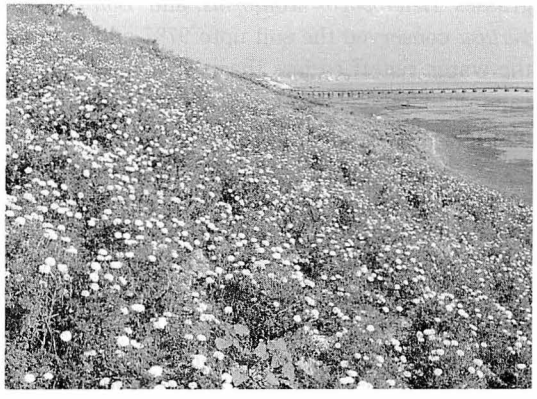

Fig. 2. Cultivation of riparian slope for marigold crop.

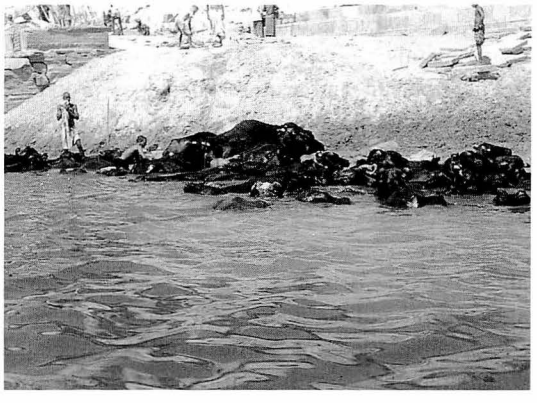

Fig. 3. Buffaloes bathing in River Ganga at Varanasi.

Vegetation and their role in soil, water and nutrient conservation

The author and his students (1962, 1970, 1985, 1989), Ambasht, Singh and Sharma (1984), Singh, Misra and Ambasht (1980), Ambasht and Shardendu (1989), Kumar, Ambasht and Shankar (1990) have made extensive studies of the impact of vegetation on the protection of the riparian slopes of River Ganga, Gomati, Chandraprabha and Rihand located within 150 km radius of Varanasi. They have also carried out the transplant experiments of the self grown components of the ground flora on sloping experimental plots and subjected them to simulated rainfall. The tech-

nique developed by Ambasht (1970) has been followed for measuring the amount of runoff soil, water and different nutrient elements from identical plant covered and bare field and experimental plots against the erosive force of simulated and natural rainfall over short and year long periods. It is found that *Cynodon dactylon*, *Sachharum benghalensis* and *Cyperus rotundus* have soil conservation value of 91 to 96%. The dicot weeds like *Euphorbia hirta* and *Alhagi camelorum* conserved only less than 30%. *Phyla nodiflora* and *Digitaria sp.* conserved 93.8 and 87.6% of soil and 72% and 65% of the simulated rainfall. The watershed vegetation on Vindhyan Hills dominated by the grasses *Heteropogon contortus* and *Bothriochloa pertusa* conserved the soil upto 97% and reduced the water runoff to less than 30% of the annual rainfall. The vegetation also conserved nitrates and phosphates and allowed only a runoff of 4.2 kg N/ha/yr and 0.28 kg P/ha/yr from the grass covered plots as against 109 kg N and 7.7 kg P/ha from the scraped bare land.

On the banks of Rihand river the herb dominated (*Ageratum conyzoides*) and shrub dominated (*Lantana camara*) conserved 92 to 94% of the soil, 68 and 76% of water and 95 and 92% of total nitrogen and 94 and 97% of available phosphorus, 82 and 92% of sodium and 88 and 92% of potassium. It is found that *Polygonum amphibium* selectively harvests out huge quantity of certain heavy metals.

The riparian and watershed slopes protected against vegetation destruction are found to retard soil, water and nutrient erosion into rivers.

Conclusions

The river corridors are most severely used and abused in the densely populated, largely rural, agricultural and fast industrially developed India. All possible kinds of biotic stresses associated with unplanned growth of cities and industries are operating. Extensive rehabilitation and research activities are currently underway. The author and his students have demonstrated in quantitative terms the conservation efficiencies of vegetation in reducing the soil erosion, excessive water runoff and nutrient losses from the riparian watershed lands. Destruction of vegetation is responsible for manifold increase in silt load and flood water into the river system. Huge quantity of nutrients are also getting washed into the river and finally to the sea. Role of certain plants in harvesting out the pollutants has also been quantified.

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