

## Classification and Management of Saline and Alkali Soils of India

S. P. RAYCHAUDHURI  
*Planning Commission, New Delhi, India*

In India saline and alkali soils occur to an extent of 6.1 million hectares (15 million acres), including about 40 000 hectares of coastal saline lands and about 1 million hectares rendered unproductive due to canal irrigation in arid and semi-arid regions, such as in the Punjab, Uttar Pradesh and Maharashtra [3].

### *General classification*

These soils have been generally classified into three classes with local names as follows:

1. *Saline soils* : These soils known as "reh" in U. P. and "thur" in the Punjab are recognised by extensive white or greyish white or ash coloured fluffy salt deposits on the surface. The decline in productivity ranging from 10 to 50% has resulted from such salinity. The salinity status of a saline profile occurring in Delhi is shown in Table 1.

2. *Saline alkali soils* : These are occasionally called "reh" and are generally called "usar" in U. P. and "kallar" in the Punjab. Outwardly the soil presents the characters of a saline type, but the subsoil is hard and is more or less impermeable to water. The morphological features of such a profile occurring in Uttar Pradesh are given below, while the composition of a saline-alkali soil profile occurring in Uttar Pradesh is shown in Tables 2 and 3.

3. *Non-saline alkali soils* : Such soils are known as typical "usar" in U. P., "rakkar" in Punjab and "chopan" in Maharashtra. Hard and compact soils of clay to clay loam texture are formed on heavier, indurated or hardened columnar subsoil which restricts the upward movement of water by capillary action and downward flow by percolation. If ground water be near the surface (within 1.5 metres), the salts return to the root zone or the surface by capillary action.

4. *Degraded alkali soil* or "solod" as per definition of such soils does not ordinarily exist in India. Degraded alkali soils in fact mean alkali soils that have regraded to the zonal soil type, a change which involves processes that may give rise to formation of an acid soil. Such conditions do not exist anywhere in India where alkali soils are encountered, except perhaps in the Sunderban areas of West Bengal, where alkali soils of marine origin may be degrading to form the acid soils of the region. Fig. 1. shows the occurrences of degraded alkali soils, saline soils, saline-alkali soils, and non-saline alkali soils in West Bengal.

### Management

In Uttar Pradesh about 1.3 million hectares are lying waste because of saline and alkali conditions. The most affected districts are Aligarh, Mainpuri, Kanpur, Fatehpur, Unnao, Etah, Etawah, Rai Bareli and Lucknow. The chief causative factors of the creation, spread and intensity of soil alkalinity in the State consist of the nearness of water table to the surface or impidence of drainage due to the presence of an indurated layer of clay or "kankar" pan in the subsoils. The morphological studies of these "usar" or sodic soil profiles reveal formation of hard solonetz-like structure at the surface (AGARWAL, MEHROTRA and GANGWAR, 1958 [2]). Profiles of these soils are generally associated with "kankar" or a hard clay pan restricting the upward movement or downward flow of water. Development of a planned system of drainage is considered a prerequisite for all projects of reclamation of such soils (RAYCHAUDHURI and DATTA BISWAS, 1955 [6]).

The reclamation of *usar* soils of Uttar Pradesh had been carried out successfully near Kanpur and Allahabad by the application of heavy doses

Table 1.  
Salinity status of a saline profile in Delhi

| Depth cm.         | Total soluble salt % | pH  | NaCl % of total salts | Na <sub>2</sub> SO <sub>4</sub> % of total salts | Na <sup>+</sup> saturation % |
|-------------------|----------------------|-----|-----------------------|--------------------------------------------------|------------------------------|
| 0-23              | 0.30                 | 8.8 | 36.8                  | 28.9                                             | 11.0                         |
| 23-46             | 0.47                 | 8.2 | 36.5                  | 25.7                                             | 7.6                          |
| 46-69             | 0.33                 | 8.3 | 32.1                  | 27.7                                             | 18.2                         |
| 69-92             | 0.32                 | 8.4 | 63.8                  | 22.0                                             | 54.5                         |
| underground water | 1.14                 | 9.1 | 61.4                  | —                                                | —                            |

of molasses containing 2% lime and 60-70% carbohydrate at the rate of 25-37 quintals per hectare (DHAR and MUKHERJEE, 1937 [4]). In a milder category of "usar" soils recourse to mechanical shattering of clay pan beyond the induration depths without up-turning the soil, supplemented

Table 2.  
Saline alkali soil of Uttar Pradesh

| Depth cm. | Description                                                              |
|-----------|--------------------------------------------------------------------------|
| 0-25      | grey clay loam, calcareous with salt deposit on surface                  |
| 25-55     | brown clay loam, drainage impeded                                        |
| 55-150    | dark brown clay, iron mottlings, compact, waterlogged, mildly calcareous |

with leaching and use of organic manure give highly encouraging results at the Government Usar Reclamation Farm, Chakeri. The treatment of soil with gypsum at the rate of 3 to 5 tons per acre followed by flushing with

water and growing a crop of *dhaincha* (*Sesbania aculeata*) as green manure and transplanted paddy also gave marked responses under average cultivators' conditions in U. P. (AGARWAL, 1957 [1]). Further experiments on the reclamation of "usar" land in U. P. at the State Usar Reclamation Farms at Dhakauni (Hardoi), Rahimabad and Katiar (Lucknow) have established that reclamation of saline alkali soil is largely a physical problem. Where the water table is not high and where the sub-soil is not totally impermeable on account of „kankar" pan or indurated clay pan, the soils can be reclaimed by leaching with water alone or preferably by leaching preceded by application of paddy straw or other undecomposed bulky organic matters.

Table 3.

Composition of a typical saline alkali soil profile of District Aligarh, Uttar Pradesh

| Horizon   | pH  | Total soluble salt % | Carbonate as Na <sub>2</sub> CO <sub>3</sub> % | Bicarbonate as NaHCO <sub>3</sub> % | Na <sup>+</sup> saturation % |
|-----------|-----|----------------------|------------------------------------------------|-------------------------------------|------------------------------|
| 1st ..... | 9.6 | 1.61                 | 0.39                                           | 0.40                                | 100                          |
| 2nd ..... | 9.5 | 0.50                 | 0.11                                           | 0.16                                | 94.4                         |
| 3rd ..... | 9.3 | 1.23                 | 0.33                                           | 0.29                                | 86.9                         |
| 4th ..... | 9.4 | 0.52                 | 0.09                                           | 0.14                                | 88.1                         |
| 5th ..... | 8.2 | 0.22                 | 0.03                                           | 0.15                                | 67.4                         |

The principle of reclamation followed by K. N. KAUL at the Banthra Farm consists of

1. Digging ditches around the field with the formation of embankment to hold the rain water,
2. Addition of organic matter in the form of powdered *Argemone mexicana*.
3. Provision of irrigation water by cavity wells. Each tube well controls about 10 hectares of land. *Argemone mexicana* powder is added at the rate of 24 maunds per acre. The *Argemone mexicana* brought down the pH from 10.0 to 7.8 within a period of 10 days after its application, but later on, the pH increased to 8.5 over a period of about one month. However with gypsum applications the pH decreased gradually and remained steady at 8.1 within a period of about a month. *Argemone mexicana* contains on oven dry basis 2% N, 0.15% P<sub>2</sub>O<sub>5</sub>, 0.35% K<sub>2</sub>O and about 4.2% water soluble organic acid.

In the Punjab over 1.1 million hectares are affected by salts (UPPAL, AGARWAL and KIBE, 1961 [7]). Due to the use of brackish waters, large areas in Ferozepur, Gurgaon, Rohtak and Hissar districts have been rendered unsuitable for agriculture by the use of excessive irrigation or when the natural drainage is impeded in the areas irrigated by canals. The water table rises to within 1.5 to 1.8 metres of the soil surface resulting in accumulation of salts on the surface. This process has resulted in the accumulation of salts in Amritsar district, Batala and Dehra Baba and Nanak tehsils of Gurdaspur district and Karnal and parts of Hissar districts. The saline and sodic soils of Punjab have high pH values, high salt concentration and high percentage of exchangeable sodium (KANWAR and BHUMBLA, 1959 [5]). The salts are predominantly carbonates and bicarbonates.

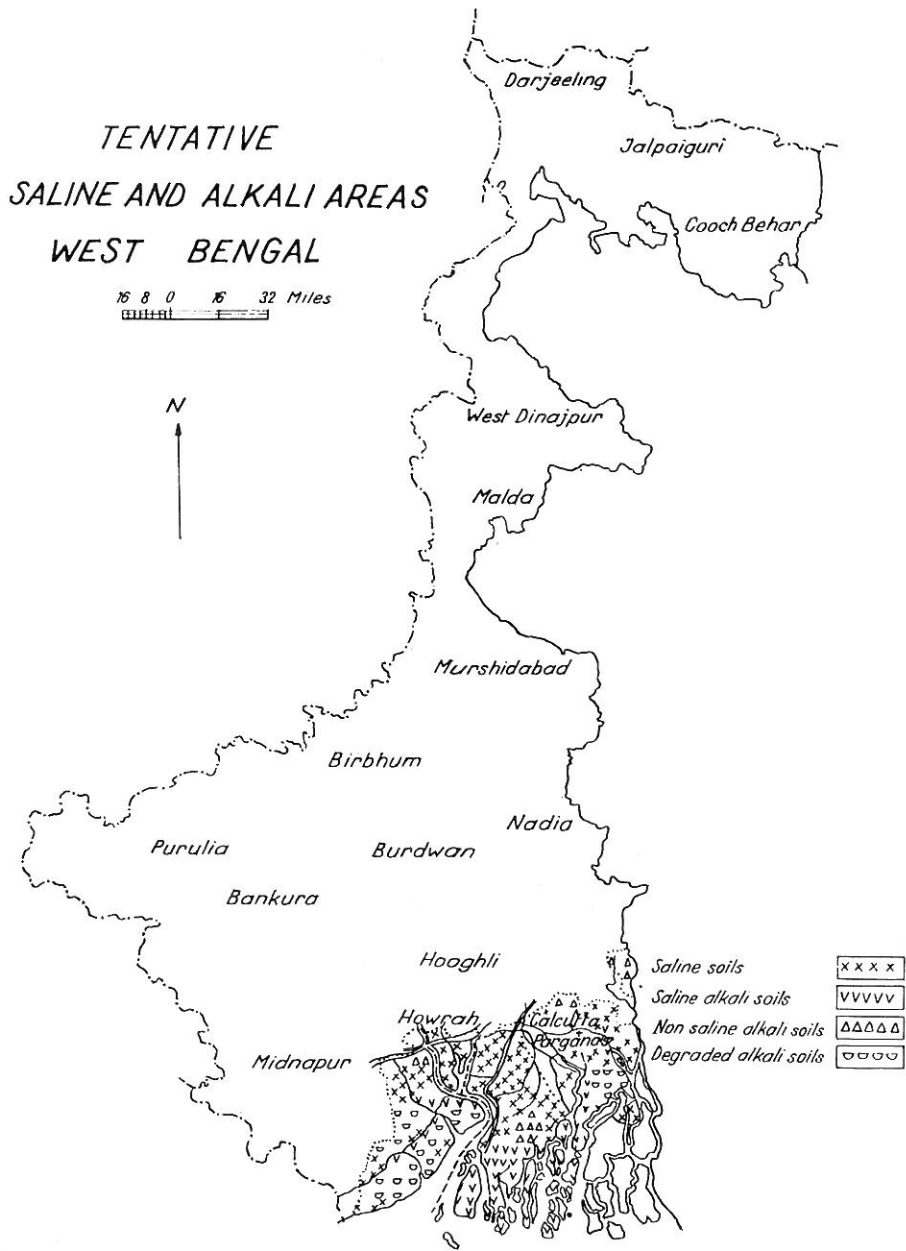


Fig. 1.

Tentative Saline and Alkali Areas, West Bengal

The methods evolved in the Punjab for the reclamation of sodic soils are:

1. The application of amendments such as calcium chloride, gypsum and press-mud and green manuring with dhaincha.

2. Agronomic practices such as rice — berseem rotation,

3. Draining out the excess water and salts.

Saline, saline alkali, non-saline alkali and degraded alkali soils of about 0.9 million hectares occur in the coastal areas in West Bengal, in the districts Midnapur and 24-Parganas including the Sunderbans area and the Northern and Southern salt lakes, near Calcutta. These soils have been affected by deposits of salt brought by tidal currents of the sea. Now these soils are bunded to prevent ingress of the sea water. Sluices have been constructed to allow the escape of rain water which dissolves and carries away some of the salt from the soil.

In Delhi State the saline and alkali soils extend over 18,600 hectares. The salinity and alkalinity have been caused by natural drainage and high water table conditions, by impermeability of the hard pan in the subsoil, and by the continuous use of brackish water wells for irrigation. The dissolved salts in many of the well waters in the area affected exceed 2000 ppm. and sodium percentage is high. One major differentiating characteristic of these soils is the nature and extent of concretionary development both of calcareous and ferruginous nature, the depths of which may vary from 1.5 to 1.8 metre.

In Maharashtra more than one hundred thousand hectares along the West Coast have been rendered saline by flooding from the sea water. About 30,000 hectares of black soil area were reported in 1938 to have become unproductive along the Deccan canal as a result of salinization.

Remedial measures suggested to control extension of water-logged and salt affected areas are

1. Canal lining,

2. Fixing intensity of perennial irrigation in relation to drainage capacities of the area,

3. Surface and subsurface drainage of salt affected areas.

In Andhra Pradesh the saline and alkali soils are of two categories:

1. About 8,100 hectares (20,000 acres) in the black soil area growing virginia tobacco where the internal drainage is very much restricted due to the clay nature of the soils.

2. About one million acres in the coastal alluvium of the districts of Srikakulam, Visakapatnam, East Godavari, West Godavari, Krishna, Guntur and Nellore. In these saline coastal alluviums it has been found that continued irrigation and cropping alone prevent the salt content from rising, if there is a permanent lowering of the water table.

The saline alkaline soils in Gujarat comprise nearly 0.8 million hectares including the estuaries of the Narbada, Tapti, Mahi and Sabarmati rivers. The chief source of salinity in Gujarat is underground water containing salt from sea deposits. Besides there are about 0.4 million hectares (1 million acres) saline areas in Kutch which have resulted from inundation by the tidal waves of the sea, especially in the monsoon season. These soils are locally known as "khar" lands. The reclamation of such soils in the State consists firstly in preventing entry of sea water and allowing rain water to go out; and secondly providing a system of drainage, scraping or flooding out of salt and application of gypsum, etc.

The total area of saline and alkali soils in Madras will be about 0.4 million hectares which occur as coastal saline in the districts of Kanya Kumary, Tinnevelly, Ramnad, Tanjore, South Arcot and Madras. They also occur as pockets in low-lying areas and in areas under irrigation. The soils have a pH of 10.0 in many cases, and excessive soluble salts, consisting mainly of carbonates and bicarbonates of sodium. Application of sulphur at the rate of 25 to 5 tons and gypsum at 25 tons per hectare have been recommended. Such applications reduce the pH, wash down the salts and enable the soils to grow good crop of "dhaincha" and "paddy".

The coastal saline soils in Orissa occur in the districts of Balasore, Cuttack and Puri and in the area inundated by the Chilka salt lake in the Ganjam district during the rainy season. The total area of such soils in the State will be about 0.4 million hectares. In Mysore the coastal salines occur to the extent of about 0.4 million hectares. The portions of Dharwar district and Bijapur taluqs are affected by what is known as „karl” soils which are saline and alkaline fairly deep clayey soils, developed as a result of excessive irrigation given on deep black soils. Improvement of these mixed saline soils after leaching requires chemical treatments of which gypsum and sulphur in combination with farm-yard manure has been found to be the best.

In Rajasthan saline alkali soils occupying 0.4 million hectares are of a varied nature. In most of the areas affected with salts there is no other source of irrigation except the ground water which is saline and, therefore, improvement of saline water and soils by chemical treatments or cultural methods will be useful in improving the soils as well as the crop yields.

The total area of saline, saline alkali and alkali lands in Bihar will be 4050 hectares. The areas of north, western and coastal parts of the alluvium north of Ganges comprising the districts of Saran, Muzaffarpur and Dharbhanga contain highly calcareous soils whose pH values are on the alkaline side and contents of available phosphoric acid and potash are generally low. Infertile patches of „usar” lands are seen in the west and central portion of the State. Application of gypsum, irrigation and drainage are the methods of reclaiming such lands.

#### Pasture development and fuel plantations in saline alkali land

„Usar” areas which may be considered unfit for agricultural purposes can be utilized for pasture development or afforestation. On stiff clay type „usar” the growth of grass and fodder is extremely slow (H. L. UPPAL et al., 1961 [7]), „khar usar” (*Sporobolus arobious*) and „usrants” (*Chlorie urigata*) are the usual grasses which grow on „usar” but die out after rain. On low lying patches and in areas remaining moist for longer periods of time, *dub* (*Cynodon dactylon*) and „gander” (*Andropogon squarrosus*) can also grow. Growing of salt bushes and trees such as „kikar” (*Acacia arabica*), „jand” (*Prosopis spicigera*), „karir” (*Capparis aphylla*) etc. can go a long way in assuaging the Kallar affliction as the salts are due to their absorption by the above mentioned plants.

Salty lands are more suitable for raising fuel plantations rather than for timber. *Dalbergia Sisso* is one of the best in this respect. Other species which can stand moderate salinity are *Porosopis juliflora*, *Tamarix articulata*, *Butea monosperma*, *Azadirachta indica*, *Zizyphus nummularice* and *Zizyphus jujuba*.

## References

- [1] AGARWAL, R. R.: Alkali soils. Indian Farming. December 1957.
- [2] AGARWAL, R. R., MEHROTRA, C. L. & GANGWAR, B. R.: Soil survey and soil work in U. P. Superintendent of Printing and Stationary, U. P. Allahabad (India). 4. 1958.
- [3] Committee on Natural Resources, Planning Commission, Govt. of India. Study on Wastelands including Saline, Alkali and Waterlogged Lands and their Reclamation Measures. 1963.
- [4] DHAR, N. R. & MUKHERJEE, S. K.: Alkali soils and their reclamation. Part. I. Agric. Livestock, India. 6. 854—855. 1936.
- [5] KANWAR, J. S. & BHUMBLA, D. R.: Proc. Seminar on Recent Advances in Agronomy and Soil Science. Simla. 1959.
- [6] RAYCHAUDHURI, S. P. & DATTA BISWAS, N. R.: Saline and alkali soils of India. Proc. Nat. Acad. Sci. 611—620. 1955.
- [7] UPPAL, H. L., AGARWAL, R. R. & KIBE, M. M.: Reclamation of saline and alkali lands. Farm. Bulletin No. 66. Ministry of Food and Agriculture. New Delhi. 1961.
- [8] UPPAL, H. L.: Reclaiming alkali waste lands. I. C. A. R. Bulletin No. 85. 1961.

## Классификация и использование засоленных почв Индии

С. Р. РАЙЧАУДУРИ

Плановая Комиссия по Использованию Почвы, Индия

## Резюме

## Распространение засоленных почв

Засоленные почвы (Saline and alkali soils) в Индии занимают площадь в 6,1 миллионов гектаров (15 млн. акров) и встречаются почти везде среди других почвенных разновидностей. После введения орошения по сети каналов в засушливых и полупустынных областях, как напр. Пуньяб, Уттар Прадеш и Махараштра, эти неплодородные территории увеличились на несколько тысяч квадратных километров, так как в верхних слоях почвы произошло накопление солей.

## Общая классификация

Эти почвы разделяются на следующие три группы по их местному наименованию:

1. Засоленные почвы (*saline soils*)

Отличительным признаком этих почв, известных на территории Уттар—Прадеш под названием «Reh», а в районе Пуньяб — под названием «Thur», являются большие белые, серовато-белые или пепельного цвета пятна выцветов солей на поверхности. Причиной 10—15% снижения плодородия этих почв является высокое содержание солей.

2. Засоленные щелочные почвы (*saline alkali soils*)

Они известны в Уттар—Прадеш также под названием «Reh», а чаще как «Usar», а в Пуньяб как «Kallar». Внешне эта почва обладает характерными чертами засоленных «saline» почв, но их подпахотный горизонт твердый и более или менее водонепроницаемый.

3. Почвы с щелочной реакцией (*alkali soils*)

Эти почвы в области Уттар Прадеш называют «Usar», в Пуньяб — «Rakkar», а в районе Махараштра — «Charan». Здесь сформировались твердые, уплотненные с глинистым и суглинистым механическим составом почвы, под которыми находится еще более плотный подпахотный горизонт со столбчатой структурой, который сильно ограничивает

капиллярное передвижение воды по направлению к верхним слоям, а также просачивание воды в нижележащие слои почвы. В том случае, когда уровень грунтовой воды находится близко к поверхности, в пределах 1,5 м слоя, соли с капиллярным током воды попадают обратно в корнеобитаемую зону и на поверхность почвы.

### Способы мелиорации

Основными способами улучшения засоленных почв являются следующие:

1. *Засоленные почвы с выцветами солей*
  - а) Срезание слоя соли,
  - б) смывание излишка соли струей воды.
2. *Засоленные почвы с высокой концентрацией растворимых солей и глубоким уровнем грунтовых вод*
  - а) Применение дождевой, или оросительной воды для орошения,
  - б) создание системы каналов для поверхностного смыва солей и дрен для отвода промытых солей.
3. *Засоленные почвы с высокой концентрацией растворимых солей и близким уровнем грунтовых вод*
  - а) Снижение уровня грунтовых вод путем откачивания воды, через открытые или трубчатые колодцы,
  - б) улучшение подпочвенного отвода вод через подпахотный горизонт и глиняные дренажные трубы в целях облегчения быстрого удаления солей.
4. *Засоленные почвы с плотным глинистым слоем, или отложениями «Канкар» в подпочве*
  - а) Глубокой вспашкой в целях разрушения плотного слоя.
5. *Плотные щелочные почвы*
  - а) Химическая мелиорация путем внесения гипса, хлорида кальция, серы и т. п.,
  - б) внесение органических веществ, как, например, «F. Y. M.», патоки, растительных остатков, зеленого удобрения (напр., *Sesbania aculeata*) и т. п.,
  - в) выщелачивание в целях удаления продуктов реакций,
  - г) глубокой вспашкой или нарезкой канав в целях разрушения уплотненного слоя.