Summary and Conclusions: (i) The physical and chemical properties of soils play an important role in the absorption and disposal of solar energy, in addition to the colour of the soil.

(ii) High coefficients of correlation oxist between maximum temperature and surface soil temperature at 1435 Hrs., in the three types of soils in all the months while the correlations between minimum temperature and surface soil temperature at 0735 Hrs. are not significant in the months of November, June, July and September.

(iii) The diurnal variation of temperature varies differently in the three soils in the different months.

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Synthetic Ion Exchangers (Amberlite Resins) Purify Water

by

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Water is chiefly used for domestic purposes, for irrigation and in industry. Yet, the same quality of water will not meet all purposes. The total solids should not exceed 500 ppm. for a water of good chemical quality for drinking purposes (U. S. Public Health Service Drinking Water Standards, 1946). Among the ions, bicarbonate is preferable to carbonate, sulphate and chloride, and calcium to sodium. For industrial purposes, waters containing calcium and magnesium salts are undesirable because such waters cause boiler-scale and corrosion of the material. Irrigation water is usually judged by three criteria; (a) boron atom concentration, (b) the ratio of sodium ion content to the sum of sodium, magnesium, calcium and potassium ions and (c) total dissolved salts. The following table gives the permissible limits for total solids and percent sodium of several classes of irrigation water as generally adopted in the U. S. A. (1).

Classes of water Grade	Approximate limits for dissolved solids	Percent sodium ($\%Na = \frac{Na \times 100}{Na + K + Ca + Mg}$)
1. Excellent	Less than 175 ppm.	<20
2. Good	175 to 500 ,,	20 to 40
3. Permissible	500 to 1400 ,,	40 to 60
4. Doubtful	1400 to 2100 ,,	60 to 80
5. Unsuitable	Over 2100 ,,	>80

Although some irrigation waters may contain higher amount of dissolved salts the injurious effect is mitigated to an extent if calcium ions predominate. Sulphate and chloride ions are preferable to carbonate and bicarbonate. Thus the quality of water desired varies with the purpose.

The character of water depends to a large extent on the source; river water differs from lake water; lake water differs from well water, and so on. The rivers rising in mountainous regions usually have less dissolved salts and those flowing in arid desert regions collect salts from the strate in which they flow. Waters from the mineral springs are usually fortified with mineral salts and the claims made regarding the curative effect of such waters for certain ailments are not wholly without justification. The impurities (dissolved salts) which must be removed from water depend on the use for which water is intended.

There are several methods for the purification of raw water, from simple mechanical filtration through sand beds adopted in municipalities, to the most modern method of electrodialysis. The latter process consists in the removal of salts from a liquid flowing between pairs of ion-selective membranes by means of an electric field. As a point of interest it may be mentioned that the research on de-salting of saline waters by electrodialysis is well advanced in the Netherlands (2) In an interesting treatise, Ellis (3) has examined the possibilities of extracting fresh water from the Ocean on a large scale with particular reference to plant construction, operating labour, maintenance, raw meterials and power. The synthetic resinous ion exchangers are the latest in this field and these are found to be eminently suitable to purify water to any desired degree, chiefly because of their high exchange capacity, their ability to withstand extremes of temperature, chemical condition and continued operation. However, their use is not limited to this field only. They are used for various other purposes also.

These resins are synthetic polymers, which are bead-like or granular particles about 0.5 mm. in diameter. Although the resins are insoluble, they react much as acids, bases or salts, but they differ from the latter in that only cations or anions are free to take part in chemical reactions. Thus, in the cation exchange resins, the anions are fixed and irreplaceable, and similarly in anion exchangers, the cations are fixed and irreplaceable. The exchangeable ion in the resin can be almost any ion. There are "single-bed" resins which are capable of ion exchange either anionic or cationic, as well as "multiple or mixed bed" resins capable of both cationic and anionic exchange simultaneously. The greater choice of these resins confirms on them almost unlimited use. Ion exchange columns are conventionally operated downflow by passing the solution to be treated through the resin bed from top to bottom and operated at a low flow rate usually (4, 5). But it is quite possible to operate in some mixed bed systems at high flow rates also (6). When the resin is exhausted of its exchangeable ions, it is regenerated by a simple process. The exchanger column is flushed with a strong solution of the ion in particular, say, if the cation exchange resin is of the sodium, the solution usually used is sodium chloride. Sodium replaces all the cations absorbed on the resin and thus the resin becomes fully regenerated. It is then resined and ready for use again and thus the ion exchange resin can be used over and over again (7). Besides, the resins achieve economy in operation cost and space, the results are completely satisfactory and regeneration can be carried out at an inexpensive cost.

The use of ion exchangers in industrial plants in advanced countries for softening of raw water is widespread (8, 9, 10, 11). Softening of water can be successfully done by passing water through a column of cation exchange resin of sodium form when the following reaction takes place:

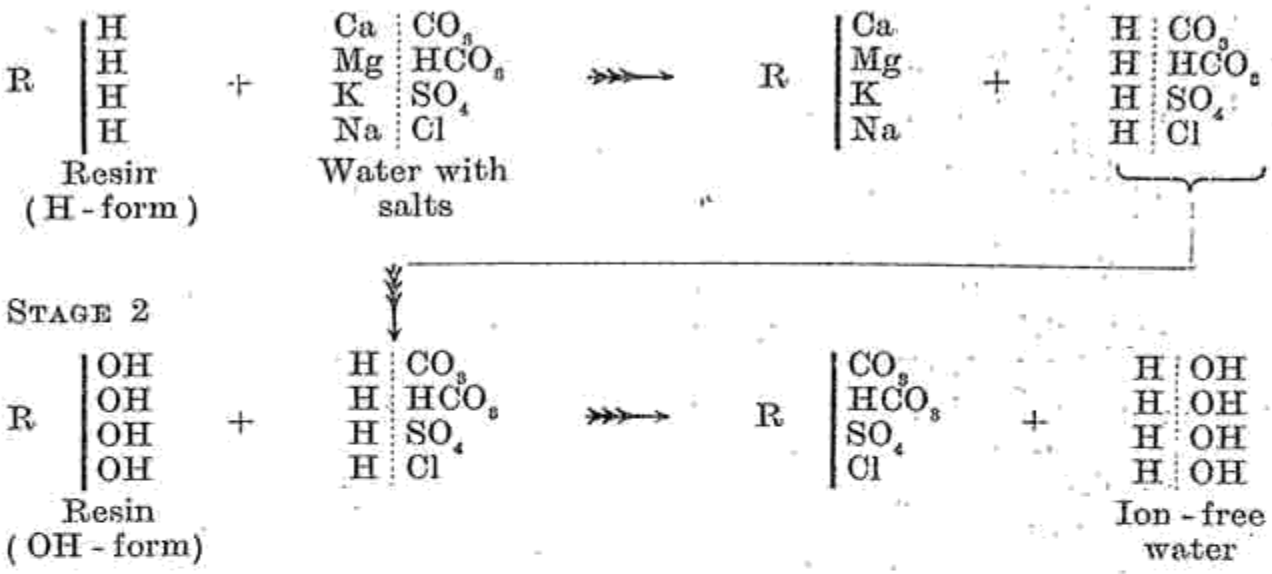
$$R\begin{vmatrix} Na \\ Na \\ Na \\ Na \end{vmatrix} + \begin{matrix} Ca & CO_3 \\ Ca & HCO_3 \\ Mg & SO_4 \\ Mg & Cl \end{matrix} \longrightarrow R\begin{vmatrix} Ca \\ Ca \\ Mg \\ Mg \end{vmatrix} + \begin{matrix} Na & CO_3 \\ Na & HCO_3 \\ Na & SO_4 \\ Na & Cl \end{matrix}$$

Resin — Hard water — Resin — Hard water

The cations, calcium and magnesium from water are absorbed on the resin and sodium ions are released from the resin. The water coming out of the exchanger column contains non-hardness producing sodium salts only.

The usefulness of ion exchangers in the preparation of chemically pure water is perhaps unexcelled. Deionization with mixed bed resin is capable of producing water of exceptional quality (12, 13, 14). The technique merely involves the passage of water through an intimate

mixture of a cation exchanger of the hydrogen form and an anion exchanger of the hydroxyl form and the reactions taking place may be represented as follows:



The cation exchanger adsorbs Ca^{++}, Mg^{++}, K^{+} and Na^{+} ions and releases an equivalent of hydrygen ions. The anion exchanger adsorbs $HCO\,3^{-}$, Cl^{-}, $CO\,3^{--}$ and $SO\,4^{--}$ ions and releases an equivalent of hydroxyl ions. The released hydrogen and hydroxyl ions combine and flow out of the exchanger column as chemically pure water. Both cationic-and anionic-exchange resins can be used to remove fluorides, boron and other harmful ions from contaminated water (15).

Besides purification of water the ion exchangers are used for a variety of purposes and some of them may be indicated. Metallic ion residues from crop protection chemicals may be removed from crushed fruit syrups. Valuable ascorbic acid can be recovered from citrus wastes by the use of suitable anion exchanger. The ion exchangers clarify, demineralise and decolorise sugar solutions resulting in increased purity of the juice as well as the increase in yield of sugar (16, 17, 18, 19). In recovering precious metals from solutions, the resinous exchanger may be used to remove the metallic ion until the capacity of the resin is depleted, after which the resin is ashed to recover the metal. The resins are insoluble, non-toxic and non-irritating, and hence are valuable therapeutic agents. They are used in the treatment of gastric and duodenal ulcers and for reducing sodium conncentration in patients with hypertension. Evidence is coming of late that the resins are used in fertility studies and Research in agriculture (20, 21).

Thus the synthetic ion exchangers have simplified a number of processes and methods in chemical technology which were rather exacting and complicated.

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