THE CAUSE OF EROSION

by Royal Lee

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Much discussion of soil erosion proceeds, I believe, without an accurate conception of what may be the basic cause of the phenomenon.

My boyhood was spent on a farm in the Driftless Area of Wisconsin, so-called because the ice-sheets all avoided this spot. It is a peculiar island of unglaciated terrain, in the midst of surrounding glacial debris. Here, the soils are of clay and sand residue, a disintegration product of the rocks in situ. Here weathering has created dendritic valley and gully systems, all veering towards the ultimate Mississippi.

About the time I began to become interested in the chemistry of soil, by reason of the introduction of the subject into the high school curriculum, I remember talking to a neighbor about our soil. He was a very intelligent and observing old gentleman who had settled there forty years before on as level a piece of land as was available on the virgin, rolling prairie, and he told me that when he first began to plow the land for corn raising, the gullies as well as the hills would be planted without a sign of erosion by run-off water. The water all appeared to be absorbed into the land.

After fifteen or twenty years, it became necessary to leave the low gully-bottoms in grass to stop the beginning of the erosion. After another fifteen years, ditches were being washed out apace, regardless of the attempts to keep sod in the gullies; and dams of old fence posts and brushwood had to be used to halt the destruction. All this on land originally selected for its gentle slopes, land topographically ideal for farming.

There is one thing here that stands out. Originally *the rain seemed to be entirely absorbed into the ground with no run-off*. Why did the water begin to run off after some years of cropping? I believe in the answer lies the basic cause of soil erosion on this kind of land.

Here we have a clay soil of a type that baked into hard, unmanageable lumps if plowed when too wet. I remember our neighbor said that when he began cultivating the land the lumps of soil fell apart on drying, whereas later they became hard and tough.

The value of this clue became apparent to me years later, when I had occasion to read E. G. Acheson's account of his investigation of the colloidal state of clay in brick making. He knew that unless straw was used in making bricks they fell apart into fragments upon drying, but he found that its function was not mechanical, as a reinforcing element, but chemical. Straw water held the clay together as well as straw.

Acheson found that clay, mixed into straw water, could not be filtered or settled out. It had become a colloidal solution. However, he also found that soluble salts (electrolytes) nullified the effect of straw water on clays. Now, maybe here is what happened to our neighbor's land. Perhaps the loss of soil salts, through cropping, resulted in the formation of a colloidal state of the soil clay, with the consequent stopping of water absorption. As a result, dried clods were brick-like rather than friable.

Other investigators have found that (1) the addition of electrolytes to an alkaline clay slip (slip is the term potters use for a liquid suspension of clay) will convert the slip to a flocculent state where it can be filter pressed or dewatered without producing a cloudy filtrate. (2) Organic colloids, such as are present in 'straw juice' prevent salts from precipitating or flocculating a mineral colloid suspension. A trace of gelatin added to a solution of colloidal gold prevents the precipitation of the latter by the addition of salt.

It seems that certain other mineral salts counteract the action by which a small proportion of organic colloid protects the integrity of a mineral colloid. If such a salt could be applied it would inactivate the organic colloid so that a still larger amount of the colloidal clay would be deflocculated and thus rendered harmless, so far as its tendency to go into suspension is concerned.

Does such a key substance exist in soils? Let us look around at some natural soil conditions. In New England, the spring floods are usually clear water. In parts of Pennsylvania I have seen two mountain streams meeting, carrying spring flood water, where one was crystal clear, the other muddy with clay. We find upon investigation that water running off land with shale or granite subsoils is usually clear, while water running off limestone country is muddy. What might be present in the shale and granite decomposition that affords a soluble salt? We find that alum is made by leaching shale; that alum is present in this clear water that refuses to take up clay. We find that alum is used as a mordant to link dyes to organic colloids, otherwise known as vegetable and animal fibers.

Perhaps the colloid in the soil that rpomotes the colloidal state of clay, the equivalent of Mr. Acheson's straw extract, is inactivated by this 'mordant'. Alum has been used to purify drinking water, for it promotes a gelatinous precipitate which 'takes with it most of the inorganic impurities, including any coloring matter which may be present.' When this process occurred in the soil, it would exhibit itself as a fixation of the salts that were acting as the 'mordant'.

Alum is present in natural shales, in decomposed granite, in many rocks of volcanic origin. If the water from alum-bearing watersheds is clear, and that from other areas is muddy, why look for some other cause of erosion? If land that had no run-off before the soil minerals were depleted by cropping, and the erosion ceased after the soil minerals were replaced, that is practical confirmation of the theory. And in our own experience we have had just that occur, in some of the run-down land we have built up. The only salts added to the soil in our case were the necessary fertilizing elements commonly used to promote the growth of legumes -- lime, raw phosphate rock and compost.

Apparently, normal soils, having the proper salts and colloidal condition of clay content, precipitate out of the water that leaches through it practically all of organic material that may be present.

E. J. Russell in his Soil Conditions and Plant Growth said: 'Practically the whole of the organic matter added to the soil by plant residues or manure remains near the surface unless carried down mechanically or by earthworms. Even when heavy dressings of dung are annually applied at Rothamsted there is after fifty years no appreciable enrichment of the subsoil in nitrogen. The purification of sewage by land treatment affords further illustration of the absorptive power of soil for organic matter.'

Evidently, clay absorbs organic matter, which in turn can absorb inorganic salts of ammonium, potassium and phosphates. This would evidently include alum. Apparently, a proper balance between these factors is necessary to maintain an ideal condition of maximum friability of soil clods on drying, with no clay carried off in flood waters.

It seems that we must have organic matter to hold the mineral elements needed by plant life, and we must have mineral salts and clay to hold the organic matter.

It is strange that a complete investigation of the factors that determine the physical properties of soil has been so neglected. It seems to be the key to two most important problems of the land -- the problem of erosion, and the problem of maintenance of fertility. Stopping erosion by this method would be really economical. The improved fertility would no doubt defray the costs many times over.

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VITAMER OR ISOTEL? BOTH?

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In the issue of Science for October 29, Dr. Roger J. Williams criticized the choice of the word 'vitamer' to 'designate vitamin forms that can replace one another.'

Rather, I believe, the word vitamer was coined to represent just what its root words mean, life-part, that part of the diet of any animal that performs the same function, regardless of the fact that quite different chemical entities may be required in different species to perform this specific effect that the vitamer under discussion is characterized for.

That is a separate purpose than that for which Dr. Williams suggests the term 'isotel'. An isotelic vitamin or food factor would be, according to his definition, a factor that can replace another in a given diet or nutrient media, for some specified species, or under a given set of circumstances. Evidently, we are in need of both terms to accurately express ourselves in dealing with the situation we are confronted with.

Vitamer A, accordingly, is that factor in any nutrient system that provides the vitamin A effect. It may be carotene for one species, kryptoxanthin for another, vitamin A_1 in salt water fish, vitamin A_2 for fresh. But for the human species, carotene is isotelic with vitamin A, for carotene can be converted into vitamin A in the human, thus can replace it in the diet of this specific species. Carotene, for the human species, therefore, would be isotelic with vitamin A. In the case of the cat, however, which can not make this conversion, carotene is not isotelic with vitamin A. A list of the vitamin A isotels for the cat would not include this factor.

The A vitamers for the cat are the isotelic substances that afford the nutritive effect of vitamin A for the cat. If the cat can only make use of one substance, there are then no vitamin A isotels for the species, but there always would be a vitamer A for any species that requires that vitamin in any form.

The term vitamer is just as hypothetical as the term carbohydrate or protein. A carbohydrate is that portion of the diet that supplies energy. It may be starch for the human, cellulose for the rabbit. Cellulose is not isotelic with starch for the human organism, but it is for rabbits and ruminants.

As cobalt and manganese are isotelic in their effect of activating enzymes, this term may be found representative for probably all classes of food factors, whether simple or complex. Vitamers, however, seem to be representative of the more complex food factors. Such of the vitamins as are found conjugated with proteins in foods seem to be relatively specific for species. The pellagra preventive vitamer is a good example.

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THE NATURAL LAWS OF HUSBANDRY

by Justus von Liebig

(Part reprinted below is from pages 90, 236, 238, 239, and 240.)

. . . 'Hydrated silicic acid loses its solubility in water by simple drying, and it frequently happens that the drainage of a marshy field will cause the siliceous plants (reeds and horsetail) to disappear. The action exerted upon the soil by hydrate of lime, or by lime slaked or fallen to powder in the air, is twofold. On a soil rich in humus constituents the lime combines, in the first place, with the organic compounds present, which have an acid reaction; it neutralises the acid of the soil, thereby causing the speedy disappearance of many weeds, such as bog-moss (Sphagnum) and reed-grasses, which fluorish in a sour soil of this kind. Simple contact with acids powerfully promotes the oxidation of metals (copper, lead, iron), while contact with an alkali prevents it (iron coated with a dilute solution of carbonate of soda will not rust). Upon organic substances, the action is the very reverse: acids prevent, and alkalis promote, oxidation or decay. Excess of lime causes the aforesaid destruction of the humose constituents.

In the same degree as the acid humus, by the action of lime, disappears from the ground, the absorptive power of the latter for hydrated silicic acid is increased; and the excess of this acid present loses its mobility in the soil.* (* In an experiment made specially for the purpose, it was found that a litre (about a quart) of forest soil, containing 30 per cent. of humose constituents, absorbed from a solution of silicate of potash only 15 milligrammes of silicic acid. But the same soil mixed with 10 per cent. of washed chalk (carbonate of lime) absorbed 1140 milligrammes; and when mixed with 10 per cent of slaked lime instead of chalk, the absorptive power was increased to such a degree, that a litre absorbed 3169 milligrammes of silicic acid.)

The action of lime, as we see, is so complex, that from its favourable influence upon one field, it is scarcely ever possible to form an opinion of its probable action upon another field, the condition of which is unknown. This is possible only when the causes of its favourable action in the first case are clearly understood.'

Pages 236 - 238 . . . 'We know, most positively, that the corn-fields in the valley of the Nile and the basin of the Ganges remain permanently fruitful, simply because nature has taken upon herself to restore the lost condition of productiveness to the soil in the mud deposited by the inundation of these rivers which gradually raises the land.

All the fields that are not reached by the river lose their productiveness unless manured. In Egypt, the amount of the crop to be expected is calculated from the height of the water of the Nile; and in the East Indies a famine is the inevitable consequence whenever there happens to be no inundation.

Nature herself, in these striking instances, points out to man the proper course of proceeding for keeping up the productiveness of the land.

The notion of our ignorant practical husbandmen that the soil contains ample store of the elements of food to enable them to pursue their system of agriculture, is due partly to the excellent quality of the land, but also to their skill in robbing it. The man who attempts to gain money by filing the weight of one gold piece from a thouasnd, cannot plead, in extenuation, that it is remarked by no one, but if discovered he is punished by the law; for everybody knows that the fraudulent act, repeated a thousand times, would ultimately leave nothing of the gold pieces. A similar law, from which, moreover, there is no escape, punishes the agriculturist who would make us believe that he knows the exact store of available food elements in his land, and how far it will go; and who deceives himself when he fancies he is enriching his field by bestowing on the arable surface soil the matters taken from the deeper layers.

There is another class of agriculturists consisting of men with a small stock of knowledge joined to a limited understanding, who, indeed, fully recognise the law of restitution, but interpret it after their own fashion. They assert and teach that part of the law only, and not the whole, applies to cultivated fields; that certain constituents, unquestionably, must be restored to the soil to keep up its productiveness, but that all the others are found in the earth in inexhaustible quantities. They generally base their opinion upon some unmeaning chemical analysis, and demonstrate to the simple agriculturist (for whom alone such disquisitions are intended) how rich his fields still are in some one or other of the mineral constituents, and for how many hundred thousand crops the store will still suffice; as if it could be of the least use for any one to know what the soil contains, if the amount of the available food elements that serve to produce the crops, which is the really important point, cannot be determined.

Pages 239-240 . . . 'The fact that many fields that happen to be rich in silicates, and in lime, potash, and magnesia, are, by the growth of corn upon the common farm-yard manuring system, drained only of phosphoric acid and nitrogen, and that the farmer need only look to the replacement of these matters without troubling his mind about the rest, has already been fully discussed. This fact no one can dispute: but it is utterly inadmissible to apply it to the case of other fields, and to make other farmers believe that they, too, need not trouble *their* minds about supplying to *their* land potash, lime, magnesia, or silicic acid, and that salts of ammonia and superphosphate of lime will suffice to restore the productiveness of all exhausted fields.

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