Some Acidity Studies in Dunes and Bogs

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Acidity studies have been a favorite "war horse" of many botanists in the last decade as is evidenced by the large number of papers which have appeared on the subject. One might wonder if the field were not almost exhausted; yet I feel that the present study is somewhat different from most papers dealing with the acidity problem, and it presents features which warrant consideration. Usually study of acidity of habitat is associated with distribution of vegetation; this time we will treat the subject purely as a habitat factor per se and present the extensive comparative phase rather than the intensive applied phase. The extensive collections of peat for fossil pollen work of eleven Indiana bogs presented an excellent opportunity to investigate the acidity factor of the various strata of the peat. The dunes studied are along the shores of Lakes Huron and Michigan, and the similarity in the pH of their soil invited a comparison with dunes of widely separated regions.

Procedure and Methods

During the year 1936-37 our botany department had a number of M.A. candidates working on pollen investigations. This necessitated the hard manual labor of collecting samples of peat at one-foot intervals, and so pH tests could easily be made of the various peat strata, the samples being placed in small vials and securely stoppered. The pH readings were made within a few days after the peat had been collected. The Youden hydrogen-ion apparatus was used. Three readings were made of each foot-level, and the results of the three readings were averaged for the figures shown in the tables. Unfortunately, the peat had to be collected in winter, and the frozen soil prevented taking soil at the surface layer. To facilitate comparison, the profiles of the bogs are plotted against one another according to upper, middle, and lower third, for the actual vertical distance differs too much in the various bogs. (Tables I and II.)

Data on dunes soil are of two sources: one source, records collected by the author on several trips along both shores of the lower peninsula of Michigan and the area about Dunes State Park, Indiana, the other source, data from published records on American and European dunes areas.

Samples of soil were taken of surface layers from the lower beach, just beyond the reach of the waves on a quiet day; from the upper beach, probably never washed by waves except during severe storms; from the environment of grasses; and from wooded older dunes. Lake water was taken at only three stations. (Table III.)

Descriptions of Bogs and Dunes Studied

Bogs.—Most of the bogs studied were within the area covered by the Wisconsin glaciation. As a whole, bogs in Indiana have suffered

much from cultural influences such as fire, grazing, and drainage. Most of them are also senescent, usually in the sedge-meadow stage. Sphagnum is present only in scattered colonies or absent entirely. Some of these bogs are burned over annually. Every one of these depression areas has from one to fourteen feet of marl at the bottom.

Dunes.—Most of the dunes were along the Great Lakes, especially along the shores of Lower Michigan. Included were also dunes from northern Indiana and the lesser sand deposits along the Straits of Mackinac. See Table III for regional location of dunes considered.

Observations

Bogs.—None of the bogs were very acid (Tables I and II), the maximum being 5.06 for the Matthews Bog. All are 6.0 or above in the middle layers. The median pH for the top layer was 6.4, for the middle 6.5, and for the bottom 7.5. Since all of the bogs had marl deposits, the bottom layers range uniformly from neutral to highly alkaline (8.2). We find, however, a progressive increase in alkalinity with increase in depth of peat, viz., 6.4 to 6.6 to 7.5. The variation between the top and the bottom layers fluctuates between one and two pH. Range of fluctuation also varies a little with depth of soil. Range at the top is 5.0 to 7.0, at the center 6.0 to 7.2, and at the bottom 7.8 to 8.2.

Dunes.—The water of Lake Michigan ranges from near neutral to highly alkaline (Table III), and while there is some variation in the acidity of the sand of the lower beach, most readings were near neutral.

TABLE I.—Showing range of pH in strata constituting the upper, middle lower third

Bogs	Range	Depth	Bogs	Range	Depth
Otterbein.....“A”	6.18–7.71	1–15	Lake Cicott.....“A”	6.09–6.87	1–10
	6.84–7.13	16–30		6.92–7.18	11–20
	7.04–7.14	31–44		6.94–7.9	21–31
Otterbein.....“B”	6.48–6.79	1–11	Lake Cicott.....“B”	6.72–7.16	1–10
	6.63–7.08	12–22		7.08–7.46	11–20
	6.84–7.06	23–32		7.29–7.63	21–29
Garrett.....“A”	5.87–6.11	1–8	Emporia.....“A”	5.82–6.24	1–7
	6.14–6.31	9–16		6.38–6.91	8–14
	6.14–7.49	17–23		6.75–7.7	15–21
Garrett.....“B”	5.84–6.48	1–8	Emporia.....“B”	5.6 –6.6	1–11
	6.02–6.18	9–16		6.5 –6.8	12–22
	5.97–7.49	17–23		6.82–7.97	23–32
Fox Parairie.....	5.7 –6.67	1–14	Bacons Sw.....III	5.25–6.84	1–8
	6.26–6.69	15–28		6.62–6.83	9–15
	6.96–7.63	29–40		6.82–7.73	17–24
Matthews.....	5.06–6.19	1–8	Bacons Sw.....IV	5.95–6.82	1–11
	6.11–6.31	9–16		6.32–6.86	12–24
	6.21–6.91	17–24		6.86–7.69	25–32
Round Lake.....“A”	6.09–6.53	1–11	Kokomo.....“A”	6.11–6.74	1–11
	6.40–6.52	12–22		5.97–6.75	12–22
	6.43–7.58	23–32		6.96–7.59	23–32
Round Lake.....“B”	6.26–6.41	1–4	Kokomo.....“B”	5.73–6.31	1–11
	6.26–6.55	5–7		6.04–6.33	12–22
	6.45–6.65	8–10		6.35–7.43	23–32
Cambridge City....“A”	6.62–7.09	1–5	Cambridge City...“C”	6.02–6.65	1–10
	6.5 –7.37	6–10		5.65–6.43	11.19
	7.64–8.21	11–14		6.04–7.85	20–28
Cambridge City....“B”	5.9 –6.82	1–18	Kates Pond.....	6.41–6.72	1–3
	6.58–6.99	19–36		6.16–6.23	4–6
	6.52–7.75	37–53		6.38–6.5	7–9

TABLE II.—Showing pH of strata at top, center and bottom of bogs

Bogs		One foot level	Center	Bottom
Otterbein	"A"	6.18	6.99	7.14
	"B"	6.5	6.92	7.06
Lake Cicott	"A"	6.09	7.09	7.85
	"B"	6.72	7.21	7.63
Garrett	"A"	5.87	6.16	7.49
	"B"	6.48	6.02	7.49
Cranberry Pond	"A"	6.14	6.69	7.7
	"B"	6.23	6.72	7.97
Fox Prairie		5.7	6.52	7.63
Bacons Swamp	III	5.25	6.62	7.41
	IV	5.95	6.77	7.26
Matthews		5.09	6.12	6 91
Round Lake	"A"	6.41	6.35	6.65
	"B"	6.53	6.5	7.58
Kokomo	"A"	6.45	6.5	7.59
	"B"	6.31	6.09	7.43
Cambridge City	"A"	7.09	6.89	8 21
	"B"	6.55	6.65	7 75
	"C"	6.65	6.43	7 85
Kates Pond		6.72	6.16	6.5

TABLE III.—Acidity of soil in various dunes areas

Location	Lake water	Lower Beach	Upper Beach	Among Grasses	Oak-pine dunes	Dunes soil in general
Sturgeon Bay Lake Michigan	7.13	6.5	6.94	6.97	7.04	
Muskegon Lake Michigan	6.86	6.63	6.69	6.94	6.87	
Dunes Park, Indiana Lake Michigan	7.85	6.89	6.29	6.65	6.74	
Mackinaw City Straits of Mackinaw		6.79	6.91			
Rogers, Michigan Lake Huron		6.58	6.65	6.94	6 52	
Blakeney Point, England		7.0			6.8	
Lübeck, Germany		7.0–7.5		7.0		Soils neutral to basic
Carrizo Sands, Texas						Surface 7.18 Subsoil 7.13
Wilcox, Texas						Surface 7.5 Subsoil 7.39
Mount Selman, Texas						Surface 7.29 Subsoil 7.19
North Carolina						4.5 to 5.

This is true for all regions listed in Table III except for the coastal plain of North Carolina. As a whole, I might summarize for all dunes with Onno, (5) "Soils are from neutral to basic, ranging mostly between 6.5 and 7.9 with most readings near neutral." A striking case of acid dunes is the one from the coastal plains of North Carolina where the pH range is between 4.5 and 5.0 (9).

Discussion

Bogs.—Bogs as a rule show acid reactions, at least in the upper layers of peat; but when we speak of bogs, it is essential to take into

consideration the stage of development and influences which had bearing upon the habitat. If a bog is young and sphagnum or other mosses still form a dense surface covering, it will in all probability be acid **(6)**, but the nature of the water will even then have a modifying influence. Water seeping from soil with much soluble calcium, as in regions underlain with limestone or soil rich in limestone debris and shell remains, tends to reduce acidity and favors marl deposits at the bottom. All of the Indiana bogs examined have apparently developed from lakes whose waters were alkaline, for all have a one to fourteen-foot marl deposit at the bottom.

Most of the Indiana bogs suffered extensive surface disturbances such as grazing and repeated fires. The leaching of the ash had without doubt reduced acidity. This is in agreement with the opinion of Ligon **(3)**, who says for the Michigan bogs, "Of mucks which produce crops there are two classes, (1) the alkaline mucks or those having an alkaline reaction caused generally by the ash produced from the burning of mucks of high lime content, and (2) the very strongly acid mucks that are low in lime and have a very high degree of acidity."

Drainage from higher margins of the bogs also carried soluble calcium into the bog proper. One might, thus, justly assume that senescent bogs, where mosses are no longer an important factor in the vegetation and where fires are of frequent occurrence, will gradually decrease in acidity.

That seepage of water from soil rich in calcium bi-carbonate and seepage from ashes after fires tend to lower acidity in these bogs is indicated by increasing alkalinity with increase in depth (Table II). The author **(6)** also pointed this out in the paper on Baxters Bog, a young bog with luxuriant growth of sphagnum. The soils of Indiana where the bogs were studied are Early and Late Wisconsin glaciation depositions, therefore, young, geologically speaking.

Visher **(8)** is of the opinion that erosion in areas covered by Late Wisconsin glaciation is of less magnitude than in the unglaciated areas of Indiana because, "Sufficient time has not yet elapsed since the Late Wisconsin to drain many parts of northern Indiana." These are the areas of "hard water," regions where water softening is an important economic problem. It is, thus, but reasonable to assume that depression areas like bogs would be influenced by water highly charged with calcium bi-carbonate. This factor is stressed by Berquist, et al., **(1)** who say, "In many places throughout the glaciated areas of Michigan, the drift or glacial debris, from the weathering of which the soil has been in large part derived, contains considerable quantities of limestone fragments, and likewise in many places is underlain with bed-rock limestone. The limestone included in the glacial drift is often found as large bowlders or may be present as small nodules and even in the form of finely ground rock flour. It is but natural, therefore, that both surface and ground waters flowing over the calcareous rocks and through the calcareous drift should have a tendency to dissolve out a great deal of the soluble calcium and the water gradually becomes impregnated with calcium bi-carbonate, $Ca(HCO_3)_2$. Since the lime-charged waters flow naturally

into basins or depressions, some of the carbon dioxide (CO_2) is liberated, and the insoluble calcium carbonate ($CaCO_3$) is precipitated and deposited on the floors of swamps, lakes, and stream channels. This deposit is known as marl.

Dunes.—The eastern shore of Lake Michigan is noted for its extensive dunes. In fact, the dunes at Glen Haven, Michigan, are probably some of the most extensive of all inland dunes. As one looks at these immense masses of quartz sand, one may think that dunes soil were acid. Nowhere in the areas studied is this the case. Of course the various locations were more or less under similar influences, but as Table III shows, the dunes of England (7), Germany (5), and Texas (4) had similar pH characteristics. There are no doubt several factors which contribute to the alkalinity of soil in active dunes of the Great Lakes area. The lakes are the source of the sand, and many shells are washed up with the sand. The shell debris is ground up, and the pulverized remains, no doubt, add to the alkalinity of the quartz sand. The limestone strata of the lake bottom contribute to the alkalinity of the water (Table III). There is the possibility that pH of dunes soil will vary with seasons and prevailing weather conditions. Fluctuations are likely to occur because of varying amounts of calcium bicarbonate in lake and seepage water. The older dunes tend to become more acid. This is probably due to decomposition of organic matter and leaching of soluble calcium in the sands. Cain (2) found that slopes in the Great Smoky Mountains became more acid with altitude, and Welch (10) reports that the higher ridges in a limestone region of Monroe County, Indiana, were quite acid. This increasing acidity with increase in altitude in rugged areas is a result of leaching of soluble calcium. The dunes of the coastal plains of North Carolina (9) are no doubt older sands to which no new shell and limestone debris is being added, and thus they will increase in acidity as soluble calcium is leached out.

Summary

1. The paper presents data on acidity of strata of bog soils at one foot intervals and of dunes about the Great Lakes.
2. Comparisons are made with pH of dunes of Texas, North Carolina, England, and Germany.
3. The pH of dunes along the Great Lakes, Texas, England, and Germany is very similar.
4. Limestone substrat, alkaline water, and pulverized shells are suggested as causes of the alkalinity of dunes sand.
5. Leaching of the soluble calcium in the dunes sand is suggested as cause of acidity in older dunes.
6. Indiana bogs examined were all senescent and none were very acid.
7. The bogs studied had from one to fourteen feet of marl deposit at the bottom.
8. Acidity decreases in all with increase in depth.
9. Absence of sphagnum and other mosses and repeated fires are probably the reasons why Indiana bogs are only slightly acid in top and middle strata of the peat.

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