STUDIES IN NITROPHILY

II. Nitrophilous Plants of Bombay

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The term 'Nitrophily' literally means love for nitrogen. A nitrophilous plant is one to which a high-nitrate concentration is *necessary*. Hence it thrives better in a high-nitrate habitat than in any other and nearly always occurs in such habitats in contrast to other plants which cannot tolerate such a high concentration of nitrates.

On the other hand a more passive view is also possible, *viz.*, that nitrophilous plants possess certain properties within them which enable them to *merely tolerate* such habitats better than many other plants.

This view, though also in keeping with the definition of love for nitrogen, is in a way very much different from it and completely changes the whole aspect of the situation. Thus we have in a sense two views diametrically opposite: nitrate factor as a rigid necessity for nitrophilous plants on the one hand and on the other hand, a mere capacity to tolerate nitrates. The question then arises, which of the two views is the correct one and upon it hangs the whole problem of nitrophily.

From the definitions advanced by various authors, we find that none of them definitely and explicitly mentions whether a high concentration of nitrates is *absolutely necessary* to a nitrophilous plant or whether it can *merely endure* nitrates in high concentrations. The confusion is due to the fact that there are degrees in nitrophily. The whole range of nitrophily stretches from plants absolutely restricted by nitrates to ones indifferent to them and yet occurring on such habitats. The plants can thus be classified in the same way as Unger (1836) classified them with regard to chalk and silica, *viz.*, (i) indifferent to such soils, (ii) partial to such soils, and (iii) restricted to such soils. Thus whether nitrates are necessary to a nitrophilous plant or otherwise, depends upon what we mean by a nitrophilous plant and upon its place in the classification.

Nitrophilous plants as understood from the plant indicator point of view are only those which *indicate and characterise* the habitat, but we have just seen that there are other plants in the lower grades of nitrophily which cannot indicate the habitat since they can also occur on other soils (Nitrate-normal or Nitrate-low). This specific property of the characteristic species to grow only in high-nitrate habitats is important, since if a high-concentration were not necessary to the nitrophilous plant and its presence was merely due to its capacity to endure nitrates, the plant as such could have no indicator value, for then it is reasonable to suppose that it would occur equally often in other habitats as well. But this is not the case as can be seen from the reports of the various workers who have described nitrophilous communities indicating high-nitrate habitats (Olsen, 1921; Sernander, Frey, Gams and Motyka, quoted from Braun-Blanquet, 1932).

Thus from the above discussion it will be clear that we cannot accept either of the above views for defining nitrophily and therefore, have evolved a formula that may enable us to define the term.

Formula Proposed

Nitrophily does not merely depend upon the capacity of the plants to accumulate nitrates but also to a large extent upon its indicator value; in other words upon the frequency of its presence in high-nitrate habitats (Bharucha and Dubash, 1951).

From earlier work, the following facts become noteworthy:—

(i) Nitrophilous plants are characterised by their *capacity to accumulate* nitrates in their tissues.

(ii) Bauer (1938) has graded them according to their capacity to *endure nitrates* in high concentrations. He has also graded them according to the *quantities* of nitrates stored in their tissues. Olsen (1921) has also used the *quantity* of nitrates as an indication of nitrophily. *Thus nitrophily can also be defined from* the *quantity of* nitrates accumulated by the plants.

(iii) Nitrophilous plants have indicator value, *i.e.*, a high-nitrate habitat can be made out from the rich growth of plants characterized by their having large quantities of nitrates accumulated in their tissues.

Thus nitrophily is governed not by one factor but by three measurable factors, *viz.*, (*a*) Frequency, (*b*) Constancy of nitrates and (*c*) the Average Nitrate-content. We shall deal with each factor separately and illustrate our hypothesis with local examples.

(*a*) *Frequency.*—This factor measures the frequency of a particular plant in all the high-nitrate localities examined. It is measured by the number of times the particular plant is present divided by the total number of high-nitrate places investigated. The number so obtained yields a relative value for the frequency of the plant in the high-nitrate habitat, *e.g.*, *Amaranthus spinosus* = 0·374, *Portulaca oleracea* = 0·1, *Euphorbia pilulifera* = 0·075, *Solanum xanthocarpum* = 0·1.

(*b*) *Constancy of Nitrates.*—It is measured as the number of times the plant gives the positive nitrate test out of the total number of times it is analysed. Thus *Amaranthus spinosus* = 0·858, *Portulaca oleracea* = 1, *Euphorbia pilulifera* = 0·5, *Solanum xanthocarpum* = 1.

(*c*) *Average Nitrate-Content.*—Without this factor, no estimate would be correct, since the concentration of nitrates in the cell-sap gives a quantitative value of the nitrate accumulating power of the plant, *viz.*, *Amaranthus spinosus*= 165 p.p.m., *Portulaca oleracea* = 155 p.p.m. *Euphorbia pilulifera* = 56 p.p.m., *Solanum xanthocarpum* = 311 p.p.m.

Employing this formula we studied a number of plants of the nitrophilous and non-nitrophilous habitats of Bombay, both phyto-sociologically and chemically.

Methods

The methods of study fall under two heads; the floristic survey and the chemical methods.

1. *Floristic Survey*.—At first all the dirty places likely to contain a high quantity of nitrates round about Bombay were surveyed prior to making a detailed study. About 20 such localities were then selected in the following places:—Lower Parel, Andheri, Jogeshwari, Bhandup, Matunga, Santacruz, Ghatkoper, Kurla, Juhu, Kandivli and Vikhroli. In most of the above-mentioned localities the vegetation formed itself into distinct groups in which case each group was considered separately and studied as a relevé. There were no limitations imposed upon the size of the relevés as long as the vegetation was uniform and well-defined.

The survey was conducted according to Braun-Blanquet and Pavillard's method as given in their Vocabulary of Plant Sociology translated by Bharucha (1930).

2. *Chemical Methods*.—Mature stem or petiole tissue of the plant was used for all analysis. These were first subjected to a spot-test with the diphenylamine-sulphuric acid reagent and then later taken for accurate analysis if the test was positive.

The spot-test was carried out according to the method of Fiegel (1939) and the accurate estimations were performed in the laboratory according to Emmert's Field method as modified by us and described by Dubash (1946).

Results

In Tables I and II the list of nitrophilous and non-nitrophilous plants are given respectively. In Table I are also shown against each species the values of the three factors which enable us to determine the degree of nitrophily of each plant. The last column gives the product of the three factors, the Nitrophily Number.

It can be seen from the above examples that each factor if considered separately would yield a different order of nitrophily. It stands to reason, therefore, that no one or two factors by themselves could give a correct idea of nitrophily. *Solanum xanthocarpum*, for example, is a plant which is rarely found in dirty places (and hence with very little indicator value) but it could easily be taken as very nitrophilous if considered solely on grounds of its average nitrate-content.

The exact range of each of these factors cannot as yet be put down mathematically until much more work is done on the subject. We

TABLE I

Nitrate Positive Plants

No.	List of plants	Family	Frequency X	Constancy of NO_3 Y	Average NO_3 content, z in ppm.	Nitrophily No. N
1	*Amaranthus spinosus* Linn.	Amarantaceæ	0·374	0·858	165	52·8
2	*Solanum xanthocarpum* Schrad.	Solanaceæ	0·1	0·1	311	31·1
3	*Boerhaavia diffusa* Linn.	Nyctaginaceæ	0·1	1·0	183	18·3
4	*Mollugo hirta* Thunb.	Ficoidæ	0·1	1·0	175	17·5
5	*Portulaca oleracea* Linn.	Portulacaceæ	0·1	1·0	155	15·5
6	*Amaranthus gangeticus* Wall.	Amarantaceæ	0·075	1·0	96	7·2
7	*Argemone mexicana* Linn.	Papaveraceæ	0·25	0·457	54·6	6·32
8	*Trianthema monogyna* Linn.	Ficoidæ	0·125	0·67	61	5·1
9	*Alternanthera triandra* Lam.	Amarantaceæ	0·1	0·65	60·9	3·9
10	*Lippia nodiflora* Michaux	Verbenaceæ	0·1	0·58	50	2·9
11	*Vernonia cinerea* Less.	Compositæ	0·05	0·7	73·8	2·4
12	*Euphorbia piliuifera* Linn.	Euphorbiaceæ	0·075	0·5	56	2·1

TABLE II

Nitrate Negative Plants

No.	List of plants	Family
1	*Asteracantha longifolia* Nees.	Acanthaceæ
2	*Blumea eriantha* DC.	Compositæ
3	*Ludwigia parviflora* Roxb.	Onagraceæ
4	*Commelina nudiflora* Linn.	Commelinaceæ
5	*Cassia Tora* Linn.	Cæsalpinæ
6	*Ipomœa aquatica* Forsk.	Convolvulaceæ
7	*Cæsulia axillaris* Roxb.	Compositæ

cannot, for instance, formulate that a certain factor is say two or three times as important as the other two. Hence all the three factors can provisionally be taken as equal in magnitude and importance till more definite data are obtained. Hence nitrophily N could be formulated as $N = A \times B \times C$, where A, B and C are frequency, constancy of nitrates, and the average nitrate-content respectively.

Only on considering the product of these three factors can the plants be graded in the descending order of nitrophily given in Table I.

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