XII.—*On the Air and Rain of Manchester.*

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[*Read May 4th*, 1852.]

Last year I read a paper on this subject, somewhat different in title, to the British Association. As a very imperfect abstract was printed I have again written the paper, giving no new facts, but using different words.

My object is to shew that there are impurities in our atmosphere which may be discovered by chemical analysis, and that the senses and general impressions are not at fault when they speak of the peculiarities of a town's atmosphere. I had shewn in a former paper that it was not a mere fancy to suppose that the air of crowded rooms was tainted, and that it contained a substance capable of nourishing organic forms, and therefore in itself organic; and although by no means a new idea, as may be shewn from old writers, I consider it of importance that these things should not rest merely on ordinary observation, but should be more and more brought under the domain of careful experiment.

It had often been said that we were unable to tell the difference betwixt good air of the finest mountain side, and the worst air of the hospitals,—or rather, we should now say, of the infected dens of large towns, so well described in various forms, of late years, to the public. It seemed to many as if the eye had obtained a mysterious power of seeing what was scarcely capable of being proved within the domain of substance, and the smell had a power of observing what was more an influence than a positive thing. These modes of

thinking are too indefinite to be considered as opinions, and they belong also to that state of mind so common to early ages, and not uncommon in our own times, which confounds the idea of substance and elements with the ideas of power and character. These words may certainly be made to bear a closely approaching signification when viewed from a metaphysical point of view, but in physical science their limits are distinct.

The air has been a fertile source of inquiry and speculation in all times; the early writers seem lost in the vastness and vagueness of the subject, and the history of opinion upon it, up almost to the present century, is like the history of some non-physical or metaphysical subject. It is a common notion that our mental part must resemble air, and we might readily make an interesting history of the indefinite ideas and confused reasoning which introduced into our language such expressions as "the spirit of wine" and "pneumatic chemistry." But here, as in many other cases, whilst the true solution has been difficult and late, the main points have been seized very early, and whilst we may fairly object to, or smile at the use of phrases which shew our opinions to be taken from those who thought, like Anaximenes, that the soul was aërial, we scarcely differ from him when we say, as we may fairly do, "that plants and animals are made of air and return to air."

We cannot say much for the increase of clearness of thought when we compare this with a description of air written (per Johnsonum Chymicum) in 1552. "Aer est spiritus, spiritus est ventus," "The air is spirit, spirit is wind." Nor even coming later, to the time of Stahl, who lived at the beginning of the last century, and who had followers, great men, also in this century, do we see it much improved. Stahl says,—"Air is nothing but æther mixed with aqueous effluvia and the exhalations of solid bodies." Also he calls it in better style, "a light dry body, mixed with various particles of saline,

sulphureous, and aqueous salts." Here, however, is brought prominently forward an opinion of long standing, the mixture of solids with the air, giving rise to the expressions, "lighter and denser," "moist and earthy," "mixed with the exhalations of the earth." "Terreni halitu miscens" are Pliny's words.

Des Cartes found it necessary, therefore, to give a more minute description of air: "We know that air can be nothing but a collection of particles of the third element—that it is a fluid very rare and pellucid," distinctly bringing it under the class of ordinary material bodies, and taking it from the sphere of mind.

The great difference of different airs, and the effect they have in the system in raising or depressing the spirits, have no doubt been causes why air should have had many indefinite notions connected with it, independent of the ordinary want of a correct definition of matter, and the peculiar difficulties in the case of a body which cannot be seen. When a person is depressed in one place, and elevated in another, he is not unwilling to believe the very poetical idea of Heraditus that "we receive our life by breathing in the air the soul of the world." And to a great extent there is a practical truth in this, as we are often found to possess more or less life according to the condition of the air.

Modern chemistry has gone far towards proving the correctness of ancient impressions, that the air goes with the blood through the whole body, and some have almost gone as far as a Greek philosopher, who said that "the soul is in the lungs."

As so many opinions have already been delivered on air, it is not easy for any one to bring forward more beautiful or more expansive ones; there is room, however, for experiments to make our ideas more definite. We hear of pure and impure air, but these phrases do not convey the same meaning to all persons. Impure air is simply air with impu-

rity in it; to some it means a different kind of air inherently impure. This vague and alchemistic notion, which did not distinctly define, was combatted in speaking of compounds generally, even by Roger Bacon, but it was not until Dalton's time that any distinct notions of compound bodies became general, notwithstanding Newton's definition of atoms.

The number of analyses of air in order to ascertain its oxygen and nitrogen, have been very great, and many also exist which determine the carbonic acid; little, however, has been done in ascertaining the other possible contents, and some eminent names have rather discouraged the idea of finding any thing, because if any thing else did exist, the amount would be too small for analysis to detect, and therefore too small for the body to be affected by it. Some such mode of reasoning has been current, but it is not in our power to tell what is the smallest amount of matter which will affect the system, and we know that exceedingly small doses affect us if taken repeatedly, although that effect is not equal to the effect of taking the whole at once.

Whatever chemistry or scientific men have said about the air, or indeed about any thing else, common sense and ordinary observation have had their force in no way diminished, and it is wiser for science to explain the large generalizations of common sense and the teachings of instinct, than to run counter to them; by which means it produces on one side at times extraordinary scepticism, and on the other extraordinary credulity.

Our senses are often much superior as tests to chemical tests, that is, we can perceive by our senses very often less than we can test; but it is not always the case, and when the amount is too small for either mode of observation, experiment has the great advantage of being able to condense and to accumulate, and so bring everything within the region of the sight. But it is not to be supposed that because we bring within the limits of a glass vessel enough of the impurities of the atmo-

sphere to allow us to see them, there is therefore any greater proof that the air had these impurities in them. It was well known before. The action on the system for so many years, producing almost a different race of men, is a stronger proof of a chemical action than any thing done in a bottle. This difference of feeling which we have in different atmospheres, may be said to be perceived by our *chemical senses*, as the effect is produced by decomposition in the system, and not by physical contact, otherwise we should feel the pain on the skin, or at furthest in the lungs. After breathing certain gases, either sulphuretted hydrogen, sulphuric acid, nitrous gases, muriatic acid, or chlorine, a certain lassitude and an inclination towards anxiety is felt; certain decompositions have been put in motion, and certain others have been arrested, which produce this result in the system, and we have been very slightly inconvenienced by their action on our ordinary senses. But it may happen also that our ordinary senses have perceived nothing at all, whilst illness, elevation, or depression of some kind, which are modes by which we feel a chemical action, prove it to have taken place.

The air of our towns generally seems to waver between these two states; in some cases it is shewn to be hurtful by our ordinary senses, in others it can only be felt in a secondary manner, or by what it is fairer to call our chemical senses. Of course I leave out here the fact that it is almost at all times visible to the eye, but there are differences of opinion as to the effect of that portion which is visible.

At the same time it must not be forgotten that there are advantages in towns which cannot be obtained out of them by the most of people—dryness caused by good drainage, and the cleanness of good sewerage.

As I said before, I have nothing which I can call actually new to bring forward here, but it does still present some novel feature. The air was not examined as such, because I had not proper conveniences for the experiments, and I was

compelled therefore merely to examine the rain. All the rain was found to contain sulphuric acid in proportion as it approached the town, and with the increase of acid the increase also of organic matter.

The existence of albuminous compounds may be traced in the rain, however carefully collected, and the still further vestiges of living creatures, minute animalcules, may be found also. These creatures are sufficient of themselves to shew the existence of phosphates, whilst sulphates and lime may be readily obtained. In examining the Thames water I often found that the readiest way of collecting the phosphates and magnesia was to wait for the animalcules to do it. When the residue of the rain is burnt, an abundant evolution of ammonia may be obtained; but I have not ascertained the amount, because it varies much, and I do not well feel able to collect all the ammoniacal salts which may have existed in the rain, as so much loss is caused by evaporation, even if an acid is present. All results hitherto obtained must have been approximative and too low.

This organic matter, however, is capable of decomposing and of forming ammonia when it falls upon the ground, and of furnishing food to all kinds of plants. There is enough therefore to grow plants scantily, although experience shews that there is not enough to produce a crop of any value. I do not regard it however as the object of nature to manure the land by rain—one more important and practical is to purify the air; and there is enough of evidence to shew us that places entirely without organic matter may become covered with it, and also to shew us that plants nourished even by rain water only may be made to grow.

This shews also the possibility of large quantities of impure matter being kept afloat in the air, indeed it is scarcely possible to obtain the vapour of water without some such impure matter. The organic matter found in the rain seems to be in perfect solution, and no doubt the more decomposed portion

of it at least is entirely so, but an exception must be made of that which is alive.

It becomes clear from the experiments, that rain water in town districts, even a few miles distant from a town, is not a pure water for drinking, and that if it could be got direct from the clouds in large quantities, we must still resort to collecting it on the ground in order to get it pure. The impurities of rain are completely removed by filtration through the soil; when that is done there is no more nauseous taste of oil or of soot, and it becomes perfectly transparent.

The presence of free sulphuric acid in the air sufficiently explains the fading of colours in prints and dyed goods, the rusting of metals, and the rotting of blinds.

It has been observed that the lower portions of projecting stones in buildings were more apt to crumble away than the upper; as the rain falls down and lodges there and by degrees evaporates, the acid will be left and the action on the stone be much increased.

I do not mean to say that all the rain is acid—it is often found with so much ammonia in it as to overcome the acidity; but in general, I think, the acid prevails in the town. But even if alkaline when it falls, it becomes acid on standing, and especially on boiling down, as the ammonia in these cases is separated from its acid.

A specimen taken in Greenheys fields, half a mile from the extreme south-west of Manchester, wind blowing west, had a peculiarly oily and bitter taste when freshly caught. A person to whom I gave some of it to taste, supposed it had been put into a glass in which castor oil had been put. I had collected the water in a large meat dish, which had been very carefully cleaned, and was then set on a stand about two feet from the ground, during the rain. Thinking it possible that some fatty matter might have been adhering to the vessel in spite of all my care, and not being inclined to believe that such an amount of impurity could be found in that place, I

used a platinum basin, which was carefully cleaned, and, to prevent all mistakes as to organic matter, kept red hot for some time. There was however no difference to be perceived from that collected in the larger vessel. The rain was very alkaline, and contained scarcely a trace of carbonic acid.

Boiling removes all taste, and standing alone removes the taste of the oily matter and leaves only the taste of smoke. The smoke here shews that it was not out of the range of chimnies, although the wind was west.

The taste was that of the flattest and most insipid water, which could not be drunk with pleasure, independently of the nauseous taste.

The water was very clear, but on standing it produced and deposited a number of organic bodies of the monad kind, small enough certainly when seen by themselves, but in clusters large enough to be seen lying at the bottom of the vessel.

The clear water above was a solution of organic and inorganic substances, giving the following results:—

Organic matter ..... 2·625 grs. per gallon.

Inorganic " .... { ·875 / 1·33 / 2·100 } in three experiments.

By boiling the carbonate of ammonia is driven off, at least this seems the only way of accounting for the loss of alkalinity.

On burning the residue after evaporation, ammonia is given off, and a strong smell of feathers, characteristic of albuminous compounds.

The ash is alkaline, with fixed alkalies, like the ashes of plants and other organic matter.

Cavendish-street, June 8th, 1851.—The taste of this water, collected of course directly into the vessel, was the same as that which comes from the roofs of the houses. The taste is nauseous and chiefly of smoke.

It contains many of the green monads, singly and in groups. These increased immensely, and were in numbers much greater than in the field rain. There were also some lengthened bodies somewhat resembling the gallionella, but I cannot speak with certainty of the species.

This water is acid, and on boiling becomes very acid, until it may be readily tasted as sour.

The residue when burnt gave off ammoniacal vapours, and shewed also the presence of albuminous compounds. The sides of the vessel were covered over with an oily or tarry substance.

The ashes were neutral, and consisted of sulphates; sulphate of lime and soda being amongst them.

These two specimens are characteristic of the places; they are not extreme points by any means. One is not very far in the town, and the other is not very far out of the town. I am sorry I have not obtained extreme cases, but the difference is sufficient as a point to start from. The one leaves alkaline ash, the other neutral ash. In the fields the amount of acid is not sufficient to neutralize the bases which are in union with the organic matter, and the residue is therefore alkaline; but in the town the amount of acid is equal, or in excess; what is in excess is driven off, and enough remains to saturate the bases, which become then neutral salts.

The increase of amount of organic matter is not so apparent from the table of quantities which I have drawn up; but I rely more on observing these living creatures, which are the sure indications of its presence. And they shew also that if there was not a great increase of it in the town, it was at least in a state peculiarly organizable.

Again, Greenheys fields, on the same day.—This water has a blackish deposit; a few monads may be seen at once; taste when first got very greasy; after standing a while this taste becomes bitter, like rotten leaves; flat, like all the speci-

mens; sickly taste begins when the greasy and bitter tastes are gone.

Alkaline also; alkalinity lost by boiling.

Nitrogenous fumes obtained on burning the residue.

Residue as before, alkaline.

Timperley, six miles distant.—Abundance of green matter at the bottom of the glass; an immense amount of green monads, mostly separate, but some in clusters.

Gave off alkaline fumes when the residue from evaporation was burnt.

Ash then strongly alkaline.

This water was strongly alkaline, and was farthest from the town; it had, however, a great deal of organic matter in it—as much as any—so that the acid seems so far to be a surer guide to the neighbourhood of the town.

Park-street, outside of the town, south-west.—Matted confervæ appeared in this specimen, on standing, with many green spots stationary and in motion.

The water alkaline, but acid on boiling.

The ashes neutral.

We are here therefore still within the town influence, but it appears that in the outskirts of the town the acid is neutralized in a great part with ammonia, as the rain does not become acid until that is driven off.

We may therefore find easily three kinds of air,—*that with carbonate of ammonia in the fields at a distance,—that with sulphate of ammonia in the suburbs,—and that with sulphuric acid, or acid sulphate, in the town.*

I need not minutely describe each specimen which I collected; there is much similarity when from the same district.