An essay on the analyses of mineral waters : particularly the recently discovered chalybeate water at Lees, near Oldham, Lancashire; with some observations on its medical properties, and a comparison between the Lees spa-water, and that of Hartfell spa-water, near Moffat, in Scotland ... / By D. Nield.

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AN

ESSAY

ON THE

ANALYSES OF MINERAL WATERS,

PARTICULARLY THE RECENTLY DISCOVERED

CHALYBEATE WATER

At Lees, near Oldham,

LANCASHIRE;

WITH SOME

OBSERVATIONS ON ITS MEDICAL PROPERTIES,

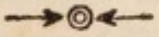
AND

A COMPARISON BETWEEN THE

Lees Spa-Water,

AND THAT OF HARTFELL SPA-WATER, NEAR MOFFAT, IN SCOTLAND.

"Aqua tamen hoc habet præcipui quod longe plurima in illam resolvi corpora queant." BUDDEUS.



By D. NIELD, Surgeon.

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An Essay,

&c.

This chalybeate Spring issues into the Brook which runs from Waterhead-Mill to Lees; the source of this water, is said to be in a coal-mine at Dirker, and this water is the loose of that mine; it runs through a tunnel from the mine to the Spa.

This Spa is about a mile and a half from Oldham, and about a quarter of a mile from the village of Lees; which village is partly situated in Lancashire and partly in Yorkshire, and is pleasantly and healthfully situated.

The compiler of this Pamphlet has to regret, that it has been so long delayed, after being announced, but he hopes the candid public will excuse this, when he assigns the the causes, or reasons for such delay. One of which is, more than usually prevalence of Typhus Fever, for the last five months, in the neighbourhood where he resides, which, together with his other avocations, have completely occupied his whole time;—another reason is, the frequent and excessive rains during the said period, which rains have occasioned a great variation in the strength of the water.

A wine pint of this water contains of solid matter from nineteen to twenty grains; of which eighteen grains are sulphate of iron,—the remainder is sulphate of lime and clay.

Some months ago, I heard a number of high sounding reports of a mineral water at, or near, Lees, in Lancashire; but as "new brooms always sweep clean," I took little notice of them. About three weeks since a gentleman sent me a bottle of the Lees Spa-water, requesting me to analyze it which I did; and found it to be an excellent tonic; and under proper regulations, will prove a valuable medicine, in almost all cases, where chalybeats are necessary.

I have been requested by a number of friends to publish an analysis of this Spa-water, which I have endeavoured to do, in as plain a manner as the nature of the subject will admit.

Should this imperfect essay, stimulate any other person to pursue the subject further, and obtain a tolerable knowledge of that highly valuable branch of natural philosophy, Chemistry, I shall be sufficiently rewarded for the little trouble I have been at.

The objects of chemical research are all the variously aggregated masses of matter, which are found in, upon, or surrounding the globe; whether existing in a state of animation or vegetation; whether they bear the marks of having been once organized, or no traces of life appear to have ever been stamped upom them. In short, the infinite varieties of the created globe, are the materials with which the chemist goes to work. A knowledge of chemistry is the concern of all men, more especially the dyer, the bleacher, the vintner, the brewer, the agriculturist, the workers in metals, the miners, and essayers: and the medical man, who is ignorant of this branch of science, is not more to be trusted with the health and life of his fellow-man, than a common labourer is to be entrusted with the repair of the fences of a farm, who cannot handle properly either the spade or the hatchet. No man ought to prescribe any medicine, who is

not acquainted with the nature and properties of the ingredients which constitute that medicine. A compounder of colours will soon lose his celebrity, if he be not so far acquainted with his art as to know, that such and such things will not decompose one another; but a medical man, who is equally ignorant of the effects produced by the combination of several drugs, dashes away, and practices with impunity, and makes a fortune; while the poor compounder of colours is ruined. The rationale of which is the following: the compounds of the colour man are exhibited to public view, and every one is capable of telling a good from a bad colour; on the contrary, the compounds of the medical man are received into the stomach, though frequently not before a decomposition of the constituents takes place; the effects or operations which take place in the stomach, are hidden from the eye of the public, though too often direfully felt by the patient.

The celebrated G———'s Mixture, is instantly decomposed on the mixing of the ingredients together. If I mistake not, there are, in that mixture, subcarbonate of potash, or salt of tartar, and sulphat of iron, or sal martis, both in a state of solution; the moment these two compounds come in contact with each other, there is a decomposition produced; the sulphuric acid (oil of vitriol) has a greater affinity for the potash than it has for the iron; hence it lets go the iron, and unites to the potash, and sulphate of potash is formed; a portion of the carbonic acid, which was separated from the subcarbonate of potash, by the superior affinity of the sulphuric acid, will probably unite to the iron, and carbonate of iron will be produced.

Every one who is acquainted with chemistry, must be sensible of the difficulty of this undertaking; the analysis of mineral waters being, with great reason, looked upon as the most difficult part of chemistry. I have, however, under-

taken the task, with greater confidence, from the reflection, that those who are best acquainted with the subject, will be the most ready to pardon any error or inaccuracy that may occur.

The substances found in mineral waters are very numerous. The most common are carbonic acid, sulphuretted hydrogen; carbonates, sulphates, muriates of soda, lime, and magnesia; and carbonate and sulphate of iron.—These are variously combined, and the water is classed acidulous, sulphureous, saline, or chalybeate, according to the ingredient which predominates in the water. Substances which seldom occur are, sulphurous acid, nitrogen gas, sulphate of clay, muriate of manganese, and siliceous earth.

Sulphurous gas is seldom found in mineral waters; when present, it is discovered by its smell, which is like the smell produced by the burning of a brimstone match; by giving a permanent red colour to a solution of litmus; or an infusion of red cabbage; and by rendering colourless an infusion of red roses. Its quantity is ascertained by expelling it, and exposing the gas, to a solution of potash; and obtaining the sulphite of potash; add to the sulphurous gas, sulphuretted hydrogen; these gases combine, and produce sulphuric acid and water.

Nitrogen gas is discovered by remaining unabsorbed when the elastic fluid, expelled from a mineral water by heat, has been exposed to the action of a solution of potash.

Sulphuretted gas is discovered by the smell, which is like that of rotten eggs, or the washing of a foul gun barrel, by the deposition of sulphur from it, on exposure to the air; or on the addition of nitrous gas, by blackening silver, or quicksilver, when immersed in it; and by giving a dark-coloured precipitate with acetate of lead. When sulphuretted hydrogen and carbonic acid gases exist together in a mineral

water, the elastic fluids obtained from the water by heat, are exposed in a tube to nitrous acid, by which the sulphuretted hydrogen is absorbed and decomposed.

The gaseous fluids are ascertained in the following manner, viz. either by a pneumatic trough and retort, or by an apparatus which was originally made use of by the late Dr. Garnett, once Professor of Chemistry at the Royal Institution. When you make use of the former method, you first ascertain how many cubic inches, or ounce measures, the retort will contain : you then fill the retort with the water to be examined, neck and all; then you place a bottle, or graduated measure, inverted, and full of water, upon the pneumatic shelf and immerse the end of the retort in the water of the trough, so as that the air discharged by the application of a lamp, or candle, to the bottom of the retort, will ascend into the bottle or measure glass.

The mineral water in the retort should never boil ; for by converting the water into steam, the measure will be upset, and all your labour lost. When the air bubbles cease to make their appearance, or to ascend, remove the lamp or candle ; and when the apparatus has cooled to the temperature of the room, you will easily ascertain the quantity of gaseous fluid : and to know what kind of gases they are, see the method of ascertaining one from another.

Dr. Garnett's method is the following :—Get a common tin pan that will hold a wine quart, that being the most convenient size ; let the top of the pan be covered with tin, so as to be perfectly air tight, except a tube in the middle, of about an inch in diameter, and two inches long ; then have the frustum of a cone inverted, and soldered round the top of the pan. Fill the pan with mineral water to the top of the tube, and fill the inverted cone with common water to within an inch of the top; then take your measure glass, or bottle, and

fill it with water, and place a piece of writing paper upon the top of the measure, or bottle, and press it gently upon the top with your hand; and you may turn the vessel with the mouth downward, and it will still be full of water; immerce the vessel into the water, and then remove the paper, and insert the tube into the mouth of the bottle, or measure glass. Place the pan upon a gentle fire, and proceed as in the other method. When the apparatus is cold, you may ascertain the quantity of gaseous fluid which the mineral water contained.

Either of these methods will answer: Dr. Garnett's apparatus is less expensive.

On examining the history of most of the mineral waters in Europe, I find that the Lees Spa-water approaches nearer in its constituents, and consequently in its medicinal properties, to the Hartfell Spa-water, than any I have seen an account of.

The Hartfell Spa-water arises from the bottom of a very high mountain of the same name, about five miles from Moffat, in Scotland. In this mountain there is a large quantity of pyrites, or sulphuret of iron.

Pyrites are composed of sulphur, oxid of iron, carbon, clay, water, &c.

All coal-mines contain pyrites; good coal contains much less than bad. Pyrites are in general called brass-lumps. Some lumps of pyrites are very beautiful, possessing the property of decomposing the rays of light, and producing all the various shades of colour in nature.

The first step to be taken, after the gaseous fluids are discovered, in order to ascertain the properties of any mineral water, should be to learn whether the water contains an uncombined acid, or alkali.

This is easily effected by taking a little of the aqueous in-

fusion of red cabbage, and mixing the Spa-water and infusion together in a clean wine glass; if the water contain an uncombined acid, it will change the purple infusion of cabbage to a red; and the colour will be more or less tense, as the water contains more or less acid; but if the water contain an uncombined alkali, the purple infusion will be changed to green; and that more or less deep, in the ratio of the quantity of uncombined alkali. Litmus, violets, harebells, foxglove, and many other vegetable blue flowers, will answer for this purpose.

If the acid which the water contains be carbonic acid gas, the gas will evaporate when exposed in an open vessel, and the colour of the infusion will return to its original purple. If the water be boiled, the gas will be carried off, and no change will take place. If the water contains carbonic acid uncombined, mix lime-water with it, and the Spa-water will become milky; a white precipitate will fall to the bottom of the vessel, which will be soluble in muriatic acid; and carbonic acid gas will be emitted.

If sulphuric acid be contained in the water, united to some base, constituting one of the sulphates, this acid is detected by dropping into the water a few drops of diluted muriate of barytes; if sulphuric acid be present, a white cloud will instantly form, and gradually fall to the bottom of the glass.

This acid is detected by a solution of the acetate of lead, in distilled water; a white cloud will form, but not so immediately as when the barytic solution is used. If alkaline, or earthy carbonates are suspected, add to the mineral water a few drops of pure nitric, or muriatic acid, and then make use of the re-agents above mentioned.

"Muriatic acid is detected by the nitrate of silver; the muriate of silver, which is formed, being, from its very sparing solubility, instantly precipitated, and giving rise to a bluish

turbid appearance. The delicacy of this, as a re-agent, is great; the most minute quantity of muriatic acid, in any state of combination, being detected. It is liable to fallacy, however, from a precipitate being likewise produced by it, from the presence either of any carbonate or any sulphate. The operation of the former is obviated by the previous addition of a few drops of pure nitric acid, which decomposes the carbonate, and expels the carbonic acid; to avoid the latter, it is necessary to decompose any sulphate, (if present,) by the addition of nitrate of barytes.

Carbonic acid, in a state of combination with the alkalies, or earths, may be discovered by the effervescence produced by the addition of sulphuric acid, and by muriate of barytes, forming a precipitate, soluable with effervescence in nitric or muriatic acid; the effervescence being in particular apparent when concentration has been produced by evaporation. The alkaline carbonates are distinguished by their power of changing the vegetable colours; the earthy and metallic carbonates, by being precipitated when the water is partly evaporated.

These are the acids usually met with in mineral waters. They are commonly combined with the fixed alkalis, lime, magnesia, argil, or clay; or with oxide of iron.

Lime is immediately precipitated, from all its combinations, by oxalic acid. Some of the mineral acids, however, either decompose this acid, or hold dissolved, the precipitate it forms with the lime; and hence, if disengaged by the decomposition itself, may have this effect. This fallacy is in a great measure guarded against by using, not the pure acid, but oxalate of potash; the potash neutralizing the acid, disengaged from the lime; oxalic acid produces a precipitate likewise with magnesia, but this takes place very slowly, even when the magnesian salt is in large quantity; while

with lime, it is immediate. Sulphuric acid is also a test to discover lime; but it is one of much less delicacy.

Ammonia and lime-water are the tests of magnesia; the former precipitating it partially, the latter entirely. In order that the lime may be an accurate test, it is necessary to remove any carbonic acid, which may exist in the water, by previously adding nitric acid; and any sulphuric acid, by muriate of barytes. Another source of fallacy more important, arises from argil, or clay, being precipitated by these tests, as well as magnesia.

The nature of the precipitate may be discovered by dissolving it in nitric, or muriatic acid, and again precipitating the solution, by carbonate of potash. If this dried precipitate be subjected to the action of diluted sulphuric, or muriatic acid, it will be immediately dissolved, if the earth be magnesia; but, if it be argil, it will dissolve slowly. Another test which discriminates between these earths is, boiling the precipitate in a solution of potash; if it be argil, it is dissolved, while magnesia remains undissolved. Succinate of ammonia, too, precipitates argil, but not magnesia. By these tests argil, or clay, is likewise discovered.

The alkalis, when in a state of combination, cannot be discovered by any striking tests, but their presence is inferred when acids are discovered in a mineral water, which are not free, and which at the same time, from the application of tests, do not appear to be combined with earthy or metallic bases. Soda is the alkali generally present. The peculiar salts, which it and potash form with the different acids, serve to distinguish them. With oxalic acid, soda forms a salt, sparingly soluble; while potash forms, with the same acid, a salt easily dissolved. With tartaric acid, on the contrary, soda forms a soluble salt; while with potash, an acidulous tartrate is formed, of comparitively spa-

ring solubility. Nitro muriate of platina, affords a test still more delicate, giving a precipitate with the salts of potash, but not with those of soda.

Silicious earth is contained in some waters, not combined, however, with any acid. A portion of alkali, likewise, generally exists in such water; but this is either in the state of carbonate, or in such small quantity that it can scarcely be considered as the solvent of the silex. This earth may be discovered by evaporating the water, and adding to the solid residuum, nitric or muriatic acid; the silex, or flint, will remain undissolved; and its nature may be still more clearly proved by fusing it with the blowpipe, with either of the fixed alkalis." *

Of the metals existing in mineral waters, iron is the principal; any other, indeed, is of very rare occurrence, and only in particular situations.

It is combined sometimes with sulphuric acid, but much more generally, is held dissolved by carbonic acid.

Dr. Saunders, speaking of the solution of iron in acids, found in mineral waters, says, "We are only acquainted with two solutions of this metal in the naturally medicated waters, of which, that in the carbonic acid, is extremely common, and found in a great variety of combinations.—That in the vitriolic (sulphuric) is very rare." † In this the Doctor is mistaken; either he has not examined coal districts, or not paid that attention which the nature of the subject requires

Let any one adequate to the task, examine coal countries, and he will find a great number of chalybeate waters, where the iron is dissolved in sulphuric acids. In fact, iron dissolved in sulphuric acid, is a natural result of the decomposition of pirytes.

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* See Dr. Murray's Elements of Chemistry. † See Dr. S.'s Treatise on Mineral Waters, page 324.

Chalybeate waters, as those impregnated with iron are named, deposit an ochrey sediment on exposure to the air. The iron is discovered by very delicate tests, principally by the infusion of galls, and the prussiate of potash; the former striking a purple colour, the latter giving rise to a blue precipitate. The latter is liable to fallacy, principally from the iron which exists in its composition, and which is liable to be evolved by an acid, so as to give rise to the blue precipitate. The former is not liable to this, or any other important fallacy, and is much more delicate; a deep colour being struck, when the iron is present, even in a very small proportion. The colour is liable to be varied by the action of various salts; alkaline and earthy carbonates, rendering it violet; neutral alkaline salts, deepening the purple tint; and sulphate of lime, rendering the precipitate at first whitish, and afterwards black. Carbonate of lime has a singular effect. If the iron be in small quantity, and at a high state of oxidation, the colour does not even appear; while if it is at a low state of oxidation, the purple tint is even heightened. By applying this test, before and after ebullition of the mineral water, we discover whether the oxide of iron has been held dissolved by carbonic acid, or sulphuric acid; as if the former has been the solvent, which will be expelled during the boiling, the oxide is in a great measure precipitated; so that the liquor, after filtration, when cold, either does not suffer the change of colour, or the tint is much less deep. The quantity of oxide may be in some measure determined by its precipitation from exposure to the air and ebullition; or, according to a more recent mode, it may be precipitated by succinate of soda; and the precipitate, calcined in a red heat, with a little carbonaceous matter, gives the quantity of oxide of iron.

Besides the methods of discovering the saline compounds,

in mineral waters, by the application of re-agents, which indicate their component parts, they may, by certain methods, be obtained in their entire state, and their quantities determined.

Evaporation is employed with this view: different substances being successively obtained, as the evaporation is carried to a greater or less extent. Thus the carbonates of lime and magnesia are usually first precipitated; afterwards sulphate of lime falls down; if after these precipitations, the liquor be drawn off and allowed to cool, the alkaline neutral salts, and the sulphate of magnesia crystalize; while muriate of magnesia and muriate of lime, if present, will remain dissolved, forming an uncrystallizable residue.

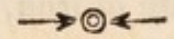
Alkohol facilitates the analyses by a similar operation: when added to the water, brought to a certain state of concentration, it throws down, first sulphate of lime, afterwards carbonate of lime, and carbonate of magnesia; and if added in larger quantity, or after a renewed evaporation, it either precipitates, or causes to crystallize, sulphate of magnesia and sulphate of soda, while any muriates remain dissolved.

Advantage too is taken of its solvent power; the solid substances being obtained by evaporation to dryness; and their separation being facilitated, by the addition of alkohol, in successive portions.

By these methods, the quantities of the solid substances contained in a mineral water are determined. These are also frequently inferred by estimation, from the precipitates afforded by the usual re-agents. Thus the quantity of sulphuric acid may be obtained from the weight of the precipitate, formed by adding muriate of of barytes; the proportion of sulphuric acid which a given weight of this salt brought to a certain state of desiccation contains, being known. The quantity of muriatic acid, may be inferred from the weight of the

precipitate, formed by adding nitrate of silver; that of carbonic acid, from the weight of the precipitate formed by water of barytes or lime; that of lime, from the weight of the oxalate of lime, precipitated by oxalate of potash; and in a similar manner, the wegihts of other substances, that can be precipitated by re-agents, in new states of combination, may be determined. The method is indeed liable to some fallacy, from the uncertainties which attend the determination of the proportions of compound salts. But it may be combined with the others, and it is only from these combined methods, that an accurate analyses can be obtained.

The following is Dr. Garnett's analyses of the Hartfell Spa-water;—and next follows the examination of the Lees Spa-water.



Dr. Garnett's account of the Hartfell Water.

This water, when taken from the well, appears quite clear, but it gradually deposits a quantity of oxyd of iron, even when closely corked; and retains at all times a large portion of this metal in solution. It has also a strong astringent and inky taste.

With re-agents it shews the following appearances:

Tincture of galls produces a very deep purple colour, nearly as dark as that of common ink: and this change of colour is as deep after the water has been boiled, as before; in which respect this water differs much from the common carbonated chalybeates. Tincture of litmus is slightly reddened. Muriated barytes produces a copious white precipitation. Lime-water gives a white precipitate of aluminous earth.

By boiling this water, a small quantity of gas arises, which is not more than five cubic inches in the gallon: and at the same time some oxyd of iron is deposited; after which the liquor remains clear, till evaporated nearly to dryness. The saline matter that remains, is a mixture of alum and vitriolated iron.

A wine gallon of the Hartfell Water, according to Dr. Garnett's analyses contains

Of sulphate of iron,	84	grains
— sulphate of alumine,	12	—
— oxyd of iron,	15	—
Total,	111	grains:

being a dram and a half, and 21 grains of foreign matter; the greatest portion of which is sulphate of iron, with a small quantity of oxyd of iron, and a still less portion of sulphate of alumine.

The analyses of this water shews that it contains only two salts, both of which however have great effect upon the human body. This spring is always strongest after heavy rains, indicating that the foreign contents are washed down through the strata of the mountain. This water, if preserved in close bottles, will keep for a long time unimpaired, except by the deposition of the excess of the oxyd of iron, and from this deposition, the chalybeate and astringent taste of the salts that remain become more sensible. As there appears to be nothing remarkable in the chemical composition of this water, it may be easily imitated by a solution of these two ingredients.

This chalybeate spring appears to possess a considerable efficacy in the cure of several dangerous diseases. The first effects of this water, are sometimes giddiness and sickness, especially when too much is taken: its operation on the bowels is uncertain, sometimes it produces gripes, and, on

first using it, a diarrhœa sometimes follows :—but this is not the general consequence, as it oftener occasions costiveness.

"This water, says Dr. Horseburgh, has been found of great service in disorders of the stomach and bowels, bloody flux, bloody urine, immoderate flow of the menses, or their suppression; fluor albus, gleet, &c. Indeed it may be advantagious in all relaxations of the solids, or diseases connected with general debility. The frequent use which practitioners now make of chalybeate medicines, and the vitriolated iron in particular, in several states of pulmonary consumption, has removed much of the apprehension, formerly entertained, of the heating powers of the preparations of steel, and has enabled Physicians to define more accurately, and confine in narrower limits, those symptoms in which this metal is injurious. Under such precautions, the Hartfell water will be found a valuable medicine for these distressing and dangerous disorders: and experience has confirmed its use.

As an external application, in old and languid ulcers, where the texture of the diseased parts is very lax, and the discharge profuse and ill-conditioned, much benefit has been derived from this vitriolated chalybeate, both internally and externally employed.

The dose of this water is less than that of most other mineral springs. It is well in all cases, and especially in delicate or irritable habits, to begin with a very small quantity, as an over dose is apt to be very soon ejected by the stomach, or to occasion griping and disturbance in the intestinal canal: and this water is never intended as a purgative. Few patients will bear more than an English pint in a day, but this may be long continued. It is often adviseable to warm this water for delicate stomachs, which may be done without materially changing its properties."

In delicate constitutions, or cachexy, or a bad habit of body, it may be adviseable to mix about an equal quantity of an infusion of ginger, with the Hartfell water: and the same observations equally apply to the Lees Spa-water; taking into account, the proportion of chalybeate ingredients in the said waters. By a judicious use of these chalybeate waters, dispepsia may, in almost all cases, be greatly relieved, and in some instances intirely removed. These chalybeates seem better calculated for medicinal purposes, than, perhaps, any other preparation of iron: as, in a great number of instances, the continuance of drinking these waters has restored livid and pallid countenances to an healthy and blooming appearance.

To children or persons of very delicate habits, it may be adviseable to begin with two table spoonful at a time, increasing the quantity as the stomach will easily bear it; and not to exceed three doses a day.

LEES SPA-WATER.

The specific gravity of the Lees Spa-water, spring water being 1—will be 1,0026.

WITH	RESULTS.
Infusion of litmus, or red cabbage,	Slightly tinged with red.
Turmeric,	No change.
Lime water,	No visible change.
Muriate of barytes,	White precipitate.
Acetate of lead,	Muddy and slight yellow tinge.
Soap dissolved,	Muddy, milky appearance.

Nitrate of silver,	The change less than in common water.
Ditto of mercury,	Ditto.
Infusion of galls,	Deep purple, nearly black.
Prussiate of potash,	Blue.
Ditto of lime,	Greenish blue.
Succinate of ammonia,	Slight amber colour.
Carbonate of ammonia,	Slightly turbid, rather yellow.
Aqua ditto pura,	Ditto, only fainter ditto.
Oxalic acid,	No sensible change.
Alcohol,	Ditto.
Oxalate of potash,	Cloudy, and slight yellow tinge.
Nitro muriate of platina,	Little immediate change, except towards the colour of the test.
Nitrate of lead,	Milky, white precipitate.
Oxalate of soda,	Slight green.

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* *DERKER COAL PIT WATER contains matter which produces a slight amber colour.*

Infusion of litmus, or red cabbage,	Brownish red.
Turmeric,	Bright amber colour.
Lime water,	No change.
Muriate of barytes,	Muddy, much white precipitate.
Acetate of lead,	Large precipitate, yellow tinge.
Soap dissolved,	Muddy, faint yellow or buff colour.
Nitrate of silver,	No sensible change of colour.
Ditto of mercury,	Ditto.
Infusion of galls,	Black.
Prussiate of potash,	Blue.
Ditto of lime,	Greenish blue.

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* This water contains too much iron, &c. for internal use.

Succinate of ammonia,	Muddy orange colour, flockulent or curdy.
Carbonate of ammonia,	Muddy yellow, more flocky.
Aqua ditto pura,	Ruddy yellow, less flocky.
Oxalic acid,	Beautiful peach green.
Alcohol,	No change of colour.
Oxalate of potash,	Muddy, dull buff.
Nitro muriate of platina,	No precipitate, colour discharged.
Nitrate of lead,	White precipitate.
Oxalate of soda,	Orange, and curdy precipitate.

The labour of analysis may be much shortened by observing, that the following salts are incompatible with each other, and cannot exist together in water, except in very minute quantities.

SALTS.

Fixed alkaline sulphates,	Are incompatible with nitrates of lime and magnesia: and muriates of lime and magnesia.
Sulphate of lime,	Is incompatible with alkalis, carbonate of magnesia: and muriate of barytes.
Allum, or sulphate of clay and potash,	Is incompatible with alkalis, muriate of barytes, nitrate, muriate, carbonate of lime, and carbonate of magnesia.
Sulphate of magnesia,	Is incompatible with alkalis, muriate of barytes, nitrate and muriate of lime.
Sulphate of iron,	Is incompatible with muriate of barytes and earthy carbonates.
Muriate of barytes,	Is incompatible with alkaline carbonates, and earthy carbonates.

Muriate of lime,	Is incompatible with sulphates, except the sulphate of lime.
Muriate of magnesia,	Is incompatible with alkaline carbonates, and alkaline sulphates.
Nitrate of lime,	Is incompatible with carbonate of magnesia, alumine or clay, and sulphates, except of lime.

Hence by casting an eye over this small table it will be easy to perceive, that whenever we find any of the alkaline sulphates in any water, it will be a loss of time to search for nitrate of lime and magnesia; or muriate of lime or magnesia; and whenever sulphate of lime is found in water, neither carbonate of magnesia or muriate of barytes need be looked for: and so of the rest of the substances in the table.

PREPARATIONS OF THE TESTS.

1st. Infuse the leaf of a red cabbage in one gill of boiling water, and when cold it will be ready for use. A little litmus dissolved in warm water, &c.

2nd. Take one dram of carbonate of barytes and reduce it to powder, in a Wedgewood or brass morter: put it into a bottle or wine glass, and add three or four drams of muriatic acid, an effervescence will then take place, and the greater part of the powder will be dissolved. Mix the clear solution of barytes with three or four times the quantity of distilled water, and it will be ready for use. Follow the above direction, only instead of muriatic acid, take nitric acid, and you will have the nitrate of barytes.

3rd. The muriate and nitrate of strontian are prepared

exactly in the same manner as the muriate and nitrate of barytes. *

4th. Infusion of galls is made by pouring a gill of boiling water upon three or four galls, reduced to powder in a Wedgewood, marble, or brass morter: and when cold it will be fit for use. The tincture is made the same way, only proof spirit, not hot, is used instead of water.

5th. Lime water is prepared by adding a quantity of water to a little quick lime: when clear, pass it through a filtre and cork it tight, and it will be ready for use.

6th. Succinic acid is obtained by dissolving salt of amber in pure water, and passing the solution through a filtre, to separate from the acid the oily part of the salt.

7th. The succinate of ammonia is prepared by adding the acid solution as obtained above, to carbonate of ammonia.

8th. Prussiate of potash may be bought at the Druggists, in a state of salt; and only requires dissolving in pure water.

9th. Prussiate of lime is made in the following manner: Take one ounce of finely powdered Prussian blue, wash it in boiling water, and add one pint of lime water: boil them together half a minute, and then filtre. This is a more delicate test of iron than prussiate of potash is.

10th. Dissolve a little oxalic acid in pure water, and it will be ready for use.

11th. To prepare the oxalate of potash: to the oxalic acid, dissolved, add a little of the subcarbonate of potash, and you have the test.

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* Barytes and strontian are stones found in the neighbourhood of lead-mines. They are of very little value except as tests. They may be had from the Druggists.

12th. Oxalate of soda is prepared by adding a little carbonate of soda, to a solution of the oxalic acid.

13th. Nitrate of silver. Take a little pure silver, cut it into small pieces, to which add as much pure nitric acid as will dissolve the silver; then add three or four times the quantity of distilled water, and the test is ready for use.

N. B. The lunar caustic of surgeons, or the nitratum argentum, is a solution of silver in nitric acid. This test may be prepared instantly, by dissolving a little of this salt in pure water. This may at any time be had from the Druggists.

14th. The nitrate of quicksilver. Take one dram of mercury, or quicksilver, and add three or four drams of pure nitric acid, and a beautiful effervescence will take place; the fume of which will be of a greenish colour: when the quicksilver is dissolved, the substance will chrystalize, which when dissolved in pure water, the test will be ready for use.

15th. Take a little turmeric, put it into a viol and fill the bottle with proof spirit: shake the bottle once or twice a day for a week, then filtre, and it will be ready for use.

16th. Tincture of red cabbage is made in the same manner, only use the leaf of the red cabbage instead of turmeric. Tincture of litmus is made the same way.

17th. Acetate of lead. Dissolve a little acetate of lead in pure water, and you have the test. N. B. Acetate of lead, is known in the shops, by the name of sugar of lead.

18th. Nitro-muriate of platinum. Dissolve platinum in nitro-muriatic acid, and to the solution add a little pure water; then the test is ready for use.

19th. Subcarbonate of potash. Dissolve this salt in pure water, and you have the test. N. B. This salt is general-

ly known by the name of salt of wormwood, or salt of tartar.

20th. Carbonate of soda is prepared in the same manner as the last.

21st. Aqua ammonia is an excellent test for copper: but this metal is never found in mineral waters, except in the neighbourhood of copper-mines. Take a single grain of sulphate of copper, (blue vitriol of the shops,) dissolve it in a pint of hot water; when cold it will be nearly colourless: add a single drop of aqua ammonia, and a beautiful blue cloud will instantly form and spread through the liquid, as the ammonia comes in contact with the copper, which is dissolved in the water.

A piece of iron well polished and perfectly clean, when immersed in a liquid containing copper, will soon be coppered all over. Doctor Elliot says, that clean and finely polished iron, detected copper in pine apple rum, which could not be ascertained by ammonia. See his Treatise on Mineral Waters.

There are a variety of other tests, by which arsenic is detected: but as this metal is never found in mineral waters, it is foreign to this Essay.

The use of these tests, or re-agents, in ascertaining the ingredients contained in mineral waters. For their respective uses, refer to their respective numbers.

1st. If there be an uncombined acid in a mineral water, the infusion of red cabbage, when mixed with such mineral water, will be changed to a red. Should the acid be carbonic, the red will vanish as the gas escapes; but if the acid be one of the mineral acids, the red colour will be permanent. If the mineral water contains an uncombined alkali, the infusion of red cabbage, litmus, &c. will be changed to green.

2nd. If the mineral water contains sulphuric acid, add a few drops of the solution of muriate of barytes, and a white cloud will instantly form and fall down to the bottom of the vessel. This acid is detected by the following tests, as well as by the muriate of barytes: but the muriate of barytes is the most delicate. Bergman says, sulphuric acid is detected by muriate of barytes, when there is not more than one millionth part of the acid in the water. Nitrate and acetate of barytes, strontian or lime, or nitrate or acetate of lead, are also tests of sulphuric acid. To render muriate of barytes a certain test of sulphuric acid, observe the following process:—The muriate must be diluted; the alkalis, or earthy carbonates, if there be any in the water, must be saturated with muriatic acid; the precipitate must be insoluble in muriatic acid. If boracic acid be suspected, muriate of strontian, or strontites must be tried, which is not precipitated by boracic acid.

3rd. Muriatic acid is detected by nitrate of silver; but the mild nitrate of mercury or quicksilver is a more delicate test,—but either of them are very good tests. To render these tests certain, the alkalis or carbonates must be previously saturated with nitric acid. If sulphuric acid be present, it must be first removed by nitrate of barytes.

4th. Boracic acid is detected by means of acetate of lead: the precipitate will be insoluble in acetic acid. To render this test certain, the alkalis and earth must first be saturated with acetic acid; and the sulphuric and muriatic acids must first be removed, by acetate of strontian, and acetate of silver.

5th. Barytes is detected by diluted sulphuric acid; the precipitate will be nearly insoluble.

6th. Lime is detected by oxalic acid, a white precipitate is produced when the water contains a very small propor-

tion of this earth: to render this test certain, the mineral acids, if any be present, must be saturated with an alkali; barytes, if any present, must be previously removed by sulphuric acid diluted. Oxalic acid precipitates magnesia very slowly, but it throws down lime instantly.

7th. Magnesia and alumine, or clay, are detected in mineral waters by the following means. Pure water of ammonia precipitates them both, but precipitates no other kind of earth. Provided the carbonic acid is first removed either by boiling the water, or saturated with an alkali. Sometimes both boiling and an alkali are necessary to separate the carbonic acid. Lime-water precipitates only these two earths, provided that the carbonic acid has been previously removed, as above stated: and the sulphuric separated by means of the nitrate of barytes.

8th. The clay may be separated from the magnesia after they have been precipitated together, either by boiling the precipitate in caustic potash, which dissolves the clay and leaves the magnesia, or the precipitate may be dissolved in muriatic acid;—then the precipitate produced by an alkaline carbonate must be dried at the temperature of 100: then exposed to the action of diluted muriatic acid, which will dissolve the magnesia without touching the clay.

9th. Silex, or flint, may be detected by evaporating to dryness, and redissolving the precipitate in muriatic acid: the flint will remain undissolved.

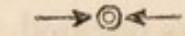
10th. The sulphates found in mineral waters are seven in number; but the sulphates of copper and ammonia very seldom occur; to detect sulphate of soda, free the water from all earthy sulphates, by evaporating the water to one half, and adding lime-water, as long as any precipitate appears. By these means the earths will all be precipitated, except lime, and the only remaining sulphate will be

sulphate of lime,—which will be separated by evaporating the liquid, till it be concentrated: and then dropping into it a little alcohol, and after filtration add a little oxalic acid: with the water thus purified, mix solution of lime; if a precipitate appears, either immediately or on the addition of a little alcohol, it is a proof, that either sulphate of potash, or soda is present; which of the two, may be determined by mixing some of the purified water with acetate of barytes; sulphate of barytes will precipitate: filtre and evaporate to dryness. Digest the residuum in alcohol, it will dissolve the alkaline acetate. Evaporate to dryness, and the dry salt will deliquice, if it be acetate of potash; but will efflouresce if it be acetate of soda. Sulphate of lime may be detected by evaporating the water, a pint, for instance, to two or three ounces; a precipitate appears, which if it be sulphate of lime, will be dissolved in 500 parts of water; and the solution affords a precipitate, with muriate of barytes, oxalic acid, carbonate of magnesia, and alcohol.

If a water contain iron and an alkali at the same time, the blue precipitate will not appear, by the addition of prussiate of potash, unless the alkali be saturated with an acid. If you suspect fixed alkalis in water, boil the water, and add muriate of magnesia, if no precipitate take place, there is no fixed alkalis; but if a precipitate is formed, there is an alkali, whether potash or soda may be ascertained, as before directed. Earthy and metallic carbonates, are precipitated by boiling the water containing them, except carbonate of magnesia, which is precipitated but imperfectly.

Examine from page 9 to 12; indeed this cannot be too firmly reveted upon the mind.

Boerhaave on the Medicinal Effects of Iron.



This metal, iron, has long been celebrated as a tonic, and for that purpose has been exhibited under various forms; and it is certainly one of the most useful remedies that can be employed in diseases proceeding from debility or laxity of the fibres. The great Boerhaave observes, that no medicine, either animal or vegetable, no diet, no regimen can produce the effects which are, in these cases, accomplished by iron. It is often used in its metallic state, and frequently in the form of a calx;* in both of which forms, when exhibited in considerable quantity, it produces very great effects as a tonic; but the most powerful and efficacious form in which this remedy is ever exhibited, is in a saline state, or combined with an acid; yet none of the saline preparations agree so universally with patients, as that in which this metal frequently exists in mineral waters, viz. in the form of aërated iron †. This constitutes an active saline chalybeate, which warms and invigorates the system, promotes appetite and digestion, and at the same time that it acts as a diuretic or diaphoretic, prevents the languor or debility which is often the consequence of these evacuations.

Dr. Home states, that the Dunse Spa-water is serviceable in flatulences of the stomach; and that a young lady, troubled with frequent eructations, swelling of the stomach, and an uneasy choking sensation, was cured of these symptoms by that water.

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* Oxide. † Carbonate of Iron.

Great benefit has also been found from that water where the stomach was so weak, as not to be capable to digest, or even retain the aliment or food. Mrs. Murdock, of Ayton, had been afflicted with pain of her stomach for many years, and had taken many medicines with little benefit. In the spring of 1749 she drunk Dunse water, and became better. However in September following, she became worse than ever: she grew so weak as to be scarcely able to walk; her stomach rejected even the lightest food. Her pain after eating became so great, that she was generally obliged to force up her victuals before they had undergone any change, so that she almost abstained from food. She had no feverish or nervous symptoms.

In this condition she went to Dunse-well in the following April, drunk a bottle of the water every morning, at first in bed. The pain of the stomach soon abated, and in a few days she ate with an appetite, retained and digested her food, and in six weeks recovered her health and strength.

For the glandular obstructions in the king's evil, Dunse water has been found serviceable. David Wright, about twelve years of age, had laboured under this disease six years: he had a running and hardness from the maxillary glands on both sides. He went to Dunse in July, and drank a bottle of the water every morning; it acted as a diuretic, and in a month, the sores were all dried up, and the parts become quite soft. He drunk the water two months longer, and is now free from his former complaint.

Instances of its curing the scab are numerous; some of which were little less virulent than the leprosy, and had resisted all medicines for many years. This water forces the irruption out, and never ceases till it has ejected the whole matter. Mrs. Smith, of Dunse, had a dry scorbutic scurf over her legs and arms, which could be scraped off with a

knife; the parts below were fiery and itchy: after trying medicines with no success, she drunk the water for six weeks, and in the January following, the disease went off, and her skin became soft and smooth.

The foregoing instances are strong cases to evince the benefit arising from the use of chalybeate waters.

With respect to the efficacy of the Lees Spa-water, three cases have come under my own observation.

Case 1st. Mrs. W. aged 43, has had a number of living children, but for some years back has had several miscarriages; the last of which was attended with a violent flooding, which reduced her so much that all hopes of her recovery were given up. To this state of extreme debility, succeeded dropsy, and an universal anasarca took place. Under these afflicting circumstances, she rejected all medicine and food: when I advised her to take two table spoonful of this Spa-water, warmed and mixed with the same quantity of the infusion of ginger; to which was added a table spoonful of port wine. This she also threw up several times at first, but in a few days she began to retain it, and from that time regularly recovered, and her anasarca gradually subsided. Some degree of costiveness took place, which was removed by occasionally taking a tea spoonful of the sulphate of magnesia, or epsom salts. The colour of her skin had become exceedingly bad, and there was every reason to believe that she laboured under a disease of the liver. After she had taken the above for five or six weeks, there was an evident amendment in her colour; she continued to use the water about three months, when her strength and complection became very much improved. In the latter part of the time, she discontinued the ginger infusion and the port wine, and she now enjoys a better state of health, and is capable

of taking more exercise and with greater ease than she had been for five or six years before. N. B. The dose of the water was increased until it became a pint a day.

Case 2nd. Mrs. S. was about 50 years of age, of a nervous and very irritable habit, who had for several years laboured under a cachexic and dyspepsic state. Last autumn she begun to take Lees Spa-water, which she continued between two and three months, by which she found very great benefit. For about three months during the winter, she discontinued the use of it, in the latter part of which time, she was approaching to her former state. She then recommenced taking the water, and is now recovering. I cannot precisely state in what quantities she has taken the water.

Case 3rd. Mrs. T. aged about 60 years, applied to me, with both hands in such a state, as is sometimes subsequent to a virulent itch, and so extremely tender, that she could scarcely endure to have them touched. Indeed, at first sight I considered it to be the relique of the itch; but on more minute examination I found there was no ground for such an opinion.

I gave her a quantity of the sulphate of magnesia, and directed her to take such a quantity as would keep her bowels pretty open, and to wash her hands at least two or three times a day in the Lees Spa-water, and to drink as much of it, as her stomach could easily bear. I requested her to call upon me again in about a fortnight, but she did not, till between three weeks and a month, when she shewed me her hands, which were perfectly healed, and the blotches and chinks were quite removed, and her hands perfectly soft and smooth.

The Opinion of W. Henry, M. D. F. R. S. of Manchester.

I have examined the water with great care, and find that a wine pint of it yields by evaporation fifteen grains of solid matter, of this one grain and a half is separated as soon as the water becomes hot, and consists of oxide of iron, dissolved by carbonic acid, which gas the heat expels. The remainder is composed of sulphate of iron, sulphate of lime, and sulphate of alumine, with an excess of sulphuric acid. The relative proportions of the three last I have not yet determined, having thought it sufficient for all useful purposes to have ascertained that the sulphate of iron considerably exceeds in quantity the sulphate of alumine.

The salts of iron and alumine are present in the Lees water in sufficient quantity to render it a powerful tonic, and the carbonic acid may enable those ingredients to sit easy on the stomach.

N. B. The water is perfectly free from any deleterious impregnation.*

* The strength of this water varies considerably at different times. I have evaporated some of this water where a wine pint has not contained more than eleven grains, and some twenty-four. There is no reason to doubt the Doctor's examination.

Appendix.

Preparation of Prussiate of Ammonia and of Iron, to be employed as a Reagent for Copper.

The most sensible reagents for copper are without contradiction the prussiates of alkali and of iron, particularly that of ammonia. This salt occasions in the nitrate of ammonia an abundant white precipitate, which is of a very beautiful red when, accidentally, an atom of copper is found in the solution. To prepare this prussiate, pour into a phial of the capacity of six ounces, three ounces of caustic ammonia, upon half an ounce of the finest and purest Prussian blue reduced to very fine powder. Stop the phial well, and leave the mixture to macerate in the cold for several days, taking care to shake it from time to time. If the deposited matter has become brown, add a new quantity of blue, and repeat this addition until the colour no longer changes. Filter the matter through paper, and pour by little and little on the residuum, an ounce of water, in order to separate all the salt. The filtered liquor is prussiate of ammonia and of iron; it has a beautiful yellow colour and a particular odour.

This prussiate is also the most sensible reagent for iron; it is even infinitely preferable to the prussiate of potass and of iron.

Tests for Lead and Copper in Wine, Cyder, Perry, &c.

Put into a crucible one ounce of sulphur, and one ounce of pure lime; and keep them in a white heat for nearly half an hour; when cold, add one ounce of the super-tartrate of potass, and boil the whole in a mattrass with some distilled water for about half an hour. Decant the supernatant liquor into small phials, adding about twenty or thirty drops of muriatic acid to each. The phials must be well stopped and preserved for use. Lead, copper, and other deleterious metals will be precipitated, of a black colour, by this liquid, if poured, in the quantity of only a few drops, into the suspected wine or cyder.

Observation. The muriatic acid is added to this test, to prevent the precipitation of iron, which might exist in the wine without any mischief resulting from its use.

Another test for these pernicious metals in wine and cyder, exists ready formed in nature. Pour into a glass of suspected wine, cyder, or perry, a few drops of Harrowgate, or Strathpeffer* water. If any lead, &c. be present, it will fall down in the state of a black precipitate, being combined with the sulphuretted hydrogen by which these waters are impregnated.

Observations. Lead is used by many wine-merchants to give an astringency to port-wine; that is, that like old port, it may appear rough to the tongue. Sometimes they hang a sheet of lead in the cask; at others they pour in a solution of acetate (sugar of) lead; for the purpose of sweetening, as they term it.

A noted London wine-merchant, acknowledged on his death-bed, that, in the long course of his extensive business,

* A very productive well in Rosshire, Scotland.

he had seen numbers of his customers fall victims to their predilection for his wines; and had remarked that no man ever lived long, who habitually drank them ! ! ! Arsenic is used to give an oily appearance to sherry, madeira, and other pale wines.

If the Harrogate water is used as a test, it will be proper, previously, to pour into the glass of wine, &c. a few drops of muriatic acid, to hold the iron in solution, as the sulphuretted hydrogen has not the power of taking it from this acid. A solution of iron may exist in the wine without the least detriment to the consumer.

To detect Alum in Red Wine.

Add to the wine a sufficient quantity of a strong solution of chlorine in water, (oxygenated muriatic acid) until it is changed to a yellow colour: let the precipitate, (composed of the chlorine and the vegeto-animal matter contained in the wine,) which immediately forms, become settled, then filter the liquor, and evaporate it to one fourth of its volume; it will, now, in consequence of the presence of the alum, have an astringent sweetish taste, and will furnish a *white* precipitate on the addition of nitrate of barytes, which is insoluble in water and in nitric acid. It will give a *yellowish-white* precipitate with pure potass, that is soluble on the addition of an excess of the potass; and a precipitate, of the same colour, with the sub-carbonate of soda, which is decomposed by the action of heat, into carbonic acid gas and alum, substances easily to be recognized by their characteristics.

T. Walker, Printer, Halifax.

ERRATA.

Page 3, line 13, after "which is," add "the"

—— 4, add to the first Paragraph by way of *Note*, "November, 1821."

—— 12, line 30, for "acids." read "acid."

—— 15 & 16, for "analyses" read "analysis"

—— 16, line 6, after "vitriolated iron," add "sulphate of iron."