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Geology and Health

Men was adjusted to the environment for more than 2 million years. A great number of chemical elements is necessary to build up human enzymes and hormones and most of these elements are the central atomium of them. Not all of them are known to us and until recently we did not even know their function. The same is true for the metabolism of animals and plants. Elements that ended up in the human food chain are those that were found to have a well-balanced equilibrium in the geological environment. In areas where this equilibrium is disturbed no life could evolve. The presence or absence of certain chemical elements determined health or illness. Recently trade and mobility made it possible for humans to settle in regions where the supply of necessary chemical elements from the soil is not sufficient. We now know, for instance, that elements such as boron, copper, molybdenum, zinc or manganese can increase the productivity of the soil for cereals and vegetables. By contrast the presence of zinc, copper, iron or cobald significant reduces the absorption by the plant of essential elements such as nickel or titanium. Equaly, the lack of manganese, boron, copper, molybdenum, selen or cobald leads to the death of plants and animals. Probably the same is true for humans. It turned out that elements that appeared to be toxical to men are rearly essentiel for human life. However, in most of the natural deposits the proportion of chemical elements is well balanced with the effect that each toxical element has ist counterpart in a nontoxical one. In the future it will be necessary to pay greater attention to the proportions of chemical elements in our environment. It will then become possible to better understand and influence the effect of those chemical elements on the human metabolism.

The Geology of Health

Again and again the question is asked as to what could have caused the extinction of species. Today we know quite a few of the catastrophies that led to extinction of 98% existing of the time like to Xixolub impact for instance. Others, such as the extinction of the Neanderthaliensis still remain a mystery. Generally speaking it can be maintained that a particular species dies out when it is no longer adjusted to its environment. This can happen through disease just as much as through catastrophies, through change in the climate or a shortage of food.

Even when there is plenty of food available essential trace elements may either be missing altogether or may occur in toxic concentration.

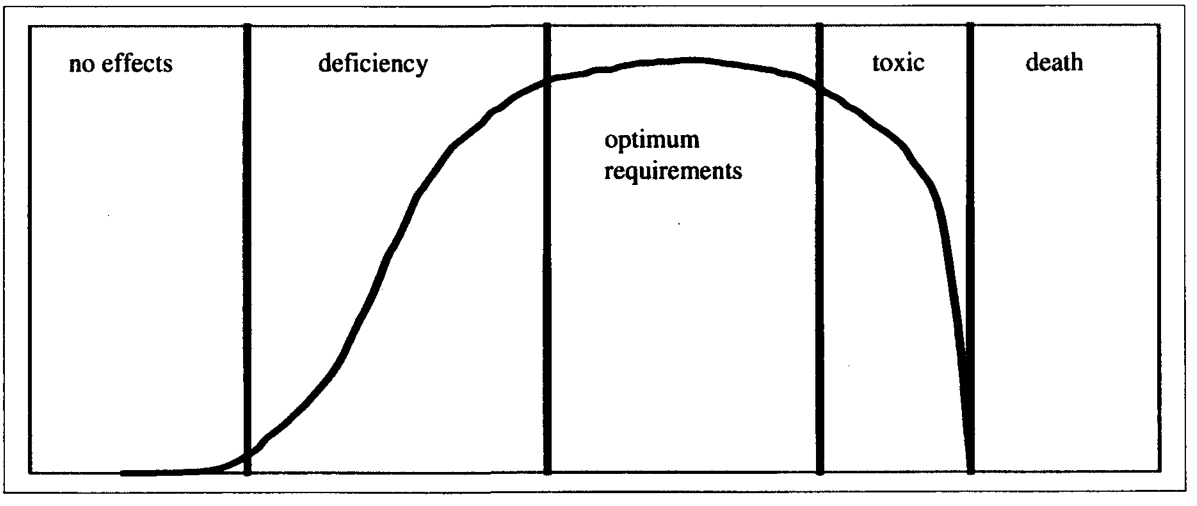

Fig.1: Physiological effects

Man - like any other form of life - has adjusted through millions of years to chemical trace elements supplied by the soil. If the supply of certain trace elements is too large the result is poisoning if it is insufficient deficiency diseases occur. The existence or lack of a particular trace element depends on the geochemical environment. Life - to no small degree - is influenced by what soil does or does not supply.

Hundred and more years ago one could be reasonably confident that the supply of chemical trace elements was just right in most populated areas. If it was not right no lasting cultures could develop.

However, colonisation and trade have changed that as it became possible to settle in areas – at least temporarily - that were less favourable to man; it also became possible, due to technology, to mine and distribute all over the globe those chemical elements that in nature mainly occur highly concentrated in deposits and that enter the circulation of elements in small quantities only.

In most populated areas the chemical elements man has adjusted to and which h absorbed from the soil in the food chain existed in a well balanced equilibrium. Since industrialisation a continuous distribution of chemical trace elements resulted in a grass imbalance which finds its expression in human health or the lack of it.

The use of chemical fertilizer was a weak attempt to minimise the damage. It should be noted, however, that it is not possible to reproduce the natural balance of the chemical elements by this method. Above all the soil develops a shortage of essential trace elements such as selenium, zinc, copper, manganese and others.

Chemical fertilization rarely is used in order to improve the health of mankind, it rather is done with the aim of increasing the productivity of the soil and thus profit.

boron for	sugar beets, rape and potatoes,
copper for	wheat and barley,
molybdenum for	vegetables rape and sugar beet,
zinc for	corn and sugar beet,
manganese for	grains and rape.

Tab. 1: Trace elements for chemicl fertilization

Indeed, the possibillty of increasing the growth of wheat with the help of copper has already been known to our forefathers.

Dr. Thalman of VOEST has been told the secret by an old farmer. He used to coat his plowshare with copperplate with the aim of increasing his profits. At may rate it has become clear that the transport of trace elements and their availabillty in the soil in plants and in animals ultimately depends on various metabolisms. It is the composition of a solution in the soil that determines the threshold of trace elements for their absorption by plants; this is so because roots can absorb those solutions only when certain trace elements act as catalysator.

The concentration an the kind of chemical trace elements existing in a particular soil are determined on the one hand by the geochemical milieu and by biological factors on the other micro-organism in the soil are active directly and indirectly. Indirectly, by producing exocellular metabolites, by synthesising high molecular humus matter and by the pH and E_h values.

Trace element	Disturbing element	reduction of intake in %
Cd^{2+}	Zn^{2+}	25
	Cu^{2+}	33
	Fe^{2+}	17
	Mn^{2+}	25
Tl^{+}	K^{+}	57
Ni^{2+}	Cu^{2+}	42
	Zn^{2+}	30
	Fe^{2+}	33
	Co^{2+}	25

Tab. 2: Influence of other elements

Out of 239 metal-insensitive bacteria 165 produced metabolites, which complexes nickel. All 59 fungi isolated from the soil behaved in this way. A great number of them stabilised Ni against hydrolysis and increased solubility by a factor of 1000 compared to inorganic nickel.

However, not all disasters are man made. Even in the nature trace elements do not always occur in an ideal balance. Even in natural soll different chemical elements can either be in short supply or they can exist in excessive amounts. Today we can relate the occurrence of certain diseases of plants and animals to the existence of certain trace elements in the soil. Already we know a great number of chemical trace elements whose shortage courses symptoms and deficiency diseases in plants, animals and man.

Element	Symptom	Deficiency disease
Mn	younger leaves brown stained	dry spot disease at Grains, Intercostal-chlorose at beets, lickmania at ruminants
B	shoot dying out, latest leaves withering	Heart - and dry rot at beets, brown-spot at cauliflower, fade of blossoms at fruit-trees
Cu	Leaves dirty, deaf ears. at more than 4 ppm molybdenum in the soil: deathbom ships, total	heart failure at cattle, moorland disease at grains, treetop dryness at fruit trees, hypocuprosis
Mo	grey leaves	disease at cauliflower
Se	necrosis at the liver, myocarditis at calves and lambs	white disease
Co	Declining wool production at sheep	bush sickness at cattle

Tab. 3: Element correlated deficiency diseases

A well known deficiency disease is the goitre caused by a shortage of iodine for instance In China the Ke-shan-Krankheit occurred in the following provinces: HE LONG JIANG, JI LIN, LIAO NING, NEI MON GOL, HE BEI, SHAN DONG, SHANXI, HE NAN, SHAANXI, GANSU, SECHEN, YUNAN, XIZANG, HU BEI and GIU ZHOU. Millions of people there died of a heart disease caused by an extreme shortage of selenium in the soil. Oral selenium substitution saved the lives and health of millions of people. In Finland, where the soil in equally is deficied in selenium, chemical fertilization was used in an attempt to add selenium to the soil.

Further imbalances of selenium in the soil are responded of the North American prairie-regions between the Golf of Mexico to Saskatschewen, of South Africa, Ireland, Israel and North Australia.

But a shortage of other essential trace elements such as zinc for instance also causes diseases. Soils deficient in zinc was found in North - Dakota, Nebraska and in the plains of Colorado. A series of several investigations was conducted in Austria as the consequence of a scandal in Arnoldstein where the pollution of the atmosphere with heavy metals was found to be particular high. One of the results was the finding that zinc and lead are genuine antagonists.

Location	Lead (ppm)	Zinc (ppm)
Arnoldstein	6,8	81
Carinthia	1,08	152
Waldviertel	10,90	151

Tab. 4: Pb and Zn conentrations in Austrian aeras

A similar result was attained with hair analysis of workers at a roasting plant in "Yuzhutalsoboto-Combinat, Plast, South - Ural the independent variable was duration of employment (in ppm). It was observed that - with time – the concentration of heavy metal increased whereas that of zinc and selenium decreased. A possible consequence of this could be suppression of defence mechanisms in the human body.

Element	1 - 5 years	6 - 10 years	over 10 years
Al	13,38	11,44	14,41
As	135	185	233
B	4,52	4,88	7,41
Bi	2,42	1,66	1,58
Ca	2968	2958	2962
Cd	0,82	1,22	1,29
Co	1,09	1,07	1,08
Sb	7,02	9,55	11,28
Cu	15,29	19,72	18,71
Fe	49,34	150,84	74,20
K	161	137	208
Li	0,12	0,13	0,10
Mg	461	420	466
Mn	3,05	3,03	4,59
Mo	0,67	0,69	0,69
Ni	2,01	0,26	1,26
P	303	255	294
Pb	4,85	8,46	10,82
Hg	0,20	0,51	0,37
Se	10,36	8,55	6,91
Ti	2,05	1,56	1,68
Zn	1366	1336	300

Tab. 5: Concentratopn of trace – elements in hairs of workers

This is where the interference of men in nature can be observed particularly well: In natural deposits, lead, cadmium and zinc never occur one without the other, so that man absorbs with the his food a well balanced ratio of noxious elements together with antagonists. Thus men's health is not endangered. It is only when these trace elements are separated from their antagonists through industrial processes that they becomes toxic. Chromium is officially known to be a toxic element. It is only recently that is was discovered in animal experiments that chromium is also essential for the living organism. Again in animal experiments chromium deficiency caused diabetes. In man a shortage of chromium causes arteriosclerosis, growth disorder and the clouding of the lens in the eye. In short, man cannot live without chromium. Usually the concentration of chromium is as follows:

10 - 90 mg/kg in the soil, 0,0003 mg/l in sea water and 0,01 mg/l in fresh water. The concentration of chromium in a non-industrialised atmosphere is around 10 µg/m³. These values are very often exceeded nowadays as the following figure shows : In rivers and streams values up to 10 mg/l were observed. Values as high as 25 mg/l were found in drinking water. The atmosphere of industrial towns contained up to 70 µg/m³ chromium and the exhaust fumes of coal firing ovens up to 2 mg/m³. Plants have a concentration of 0,02 - 14 mg/kg dry weight chromium.

However, for the diet of animals and man the valence of chromium is important. Biologically active chromium is found in the non-refined syrup made of sugar cane and sugar beetroot, in wheat germ, in black pepper and in brewers yeast. Those substances are thus helpful for avoiding symptoms and deficiency diseases. Fruit are known to contain very little chromium. In food derived from animals chromium is biologically available to different degrees. The highest concentration of biologically active chromium was found in liver and in cheese. In the adult human body the chromium content around 600 µg. Higher concentrations were found in human hair, in the liver and an the spleen. The German society for Nutrition has estimated the following daily needs of chromium for:

babies up 6 month	10-40 µg
infants up to 14 month	20-60 µg
Children between age of 1-3	20-8 µg
Children between age of 3-6	30-120 µg

Tab. 6: Faily neds of chromium for children

The question at which concentration on the soil chromium begins to be harmful must be seen in the contact of its biological avallability. It is well known that fertilisation with calcium hydroxide and phosphate reduces the plants sensitivity to chromium. In man the simultaneous administration of phosphate, calcium and iron does not make sense due to the action of their antagonists. Only very low concentrations of chromium were found in the edible parts of plants in solis that have been heavily fertilised with chromium. Spinach had the highest concentration of chromium, up to 23 mg/kg dry weight. In other plants substantially lower chromic concentrations were observed under identical conditions. The maximum concentration of 0,5 mg/kg was found in the grain of winter-rye.

Chromium in the form of glucose-tolerance-factor (GTF) is easily absorbed from the diet, as such it is also able to overcome the placenta barriere. In a biological milieu chromium (VI) is reduced to chromium (III) with possible damages due to oxidation. By contrast, chromium (VI) can penetrate biological membranes with ease thus reaching the inside of the cell. Chromium (III) cannot do such things and it is therefore very little toxic. Recently, suspicious could be confirmed that chromium once it has penetrated the cell as chromium (III) can turn mutagenic and thus carcinogenic. So, the relative harmlessness of chromium 8III) could be explained with its inability to penetrate biological membranes.

In 1957 SCHWARZ and MERTZ discovered so-called glucose-tolerance-factor (GTF) a substance that is next to insulin - important for the glucose metabolism. Later they found that the active part of GTF was non other than chromium (III), but the exact structure of GTF still remains to be discovered. Next to its role for the metabolism of glucose chromium also seems to play a part in the metabolism of fat. It appears to delay the onset and development of arteriosclerosis. In 1978 NEWMAN at al. Found a significant correlation between a low level of chromium in the blood serum of arteriosclerosis of the coronary vessels of man. According to findings brewer's yeast - rich in GTF - increases the level of HDL cholesterol and decreases that of LDL cholesterol in men, both reactions that are believed to reduce the risk of arteriosclerosis.

The company Biopan commissioned a study to investigate the effect of regularly administrated chromium an the metabolism of carbohydrate. Patients suffering from diabetes mellitus type II and hypocholesterinanemia were given 200 micrograms of chromium (GTF) before lunch during 6 weeks. The data was analysed by 7 Austrian physicians . Blood sugar level were measured at the beginning of the study and 2 and 6 weeks afterwards. On average, a reduction of blood sugar level first to 84,1 % and later to 76,2 % of the original level was observed. To summarise those findings: it seems helpful to prescribe chromium (GTF) to patients suffering from diabetes type II and high level of cholesterol but low HDL level. A low-calorie-diet, usually recommended for such patients, further reduces the chance of taking in sufficient chromium. As the study has shown this constitutes an additional risk-factors.

Refined sugar is especially bad because the naturally high concentration of chromium / GTF of sugar beetroot and sugar cane is lost. Chromium as a compared of GTF is a trace element that improves the effect of insulin so that it becomes possible to regulate blood sugar levels. Less clear is the effect of chromium on the metabolism of fat; but as the study has shown chromium also has a function here which justifies its cautions use. It is interesting to note that the plants with the highest concentration of chromium are also that are the basis for the production of sugar namely sugar beetroot and sugar cane. Both would contain sufficient chromium to produce GTF insufficient quantity to counteract the essentially harmful effect of sugar. However, by refining, non extracts with great success the artificial nature has provided. Tellurium is a rare element on earth. It takes 75th place among the other elements and belays to group VI in the periodic system together with oxygen, sulphur and selenium, all elements of biological interest. Oxygen is a component of water as well as protein and sulphur is essential for proteins. But we only learned recently that selenium is the central atomium of glutathionperoxidase, an enzyme that protects the organism from harmful radicals by getting rid of the waste products of oxidation. It is also believed to slow down ageing and to present coronary heart disease. A shortage of selenium causes cancer at a significant higher rate.

With the analytical methods of the late 60s it was not possible to detect tellurium either in sea water or in the soil, but it could be found in ash of coal. It was hypothesised that plants take up this element and that is accumulates during coal formation.

organ	µg/g	total in the organ mg
muscle	0,63	18,90
intestinal region	0,50	1,00
brain	1,88	2,82
liver	4,36	7,41
lung	0,99	0,99
kidney	0,88	0,26
heart	0,83	0,25
bones	77	539
fat	1,8	18

Tab. 7: Tellurium in human samples

So it is astonishing to find tellurium levels as high as 1035 ppm in the ash of human liver using neutron activation analysis. Lower, but still remarkably high levels of tellurium were detected in bone and kidneys and lung tissues as well as in the ovaries and testicles of men. It seems not farest to ask: could it be that tellurium is as essential a trace element for men as is selenium?

To find an answer to this question investigations with samples of human organs as well as with food samples were carried out at the institute of physiology in New Hampshire. The largest concentration of 9 % was detected in bone tissues followed by muscles and fat with 3 % and liver with 1,2 %. It was aestimated that the human body contains around 600 mg of tellurium. If this turns out to be correct tellurium would be one of the most frequent trace element in the human body together with iron, zinc and rubidium. It would be twice as frequent as zirconium, four times as frequent as strontium and six times as frequent as copper whereas manganese only for a thirteenth and chromium of a hundredth of this value.

Wet ashed plant	µg/g
Red onion	12,96
White onion I	5,50
White onion II	14,31
Little onions	1,75
Little onions, superphosphat fertilised	5,45
Garlic I	72,86
Garlic II	71,30
Garlic III	30,97

Tab. 8: Te contents in vegetables

As things stand, tellurium seems to be a highly important trace element for men. Indeed, quite remarkable quantities of tellurium have been found in the human food chain: Tellurium was found in human muscle tissues but not in the muscles of animals, nor in the most sea food. We do not know yet by what mechanism tellurium is absorbed by plants. Relatively high levels of tellurium were found in leek plants:

For a long time the healthy compound of garlic has been believed to be its high content of selenium. New studies, however, have led us to believe that rather than selenium it is the tellurium compound of garlic which is responsible for the biological positive effect even though we can not explain it yet. However that may be, several studies have shown that tellurium blocks the emphasis of cholesterol.

In studies of the university of Bar-Ilan, Ramad Gab, Israel, ammoniumtrichloro tellurates, called ACE 10, showed an immunostimulating effect. Thus same substance has an anti-tumour effect in rats without any toxic side effect. In addition it caused an increase of human lymphocytes and of T 4 cells in vitro. Running studies with AIDS- and cancer patients who were injected with 2, 3 and 5 mg/m³ of the above mentioned tellurates 3 times a week did not show any side effects, but an increase of CD4 cells was observed as well as an improvement in the CD4/CD ratio. Patients furthermore felt significantly better.

Currently the US food administrations investigating the modulating effect of this tellurium compound on the immune system as possible drug against AIDS.

Anyhow, one thing has become clear: further investigations will be necessary to fully explain the effect of tellurium and its deviates but already the success with cancer and AIDS therapies is encouraging. In folk-medicine garlic - rich in selenium and tellurium has long been used preventionely as well as a remedy against certain illness just as garlic has been used as a staple food in different cultures. This leads us to conclude that men must have adjusted to tellurium through evolution.

Very often though it is not so much the low level of a particular trace element that is detrimental to health but rather the simultaneous low level of several trace elements at one time. In the future therefore we should pay more attention to the balance of certain elements such as Cu/Mo, Zn/Co or Zn/Cu.