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RESEARCH ARTICLE

Nail as a Diagnostic tool to detect Heavy Metal Accumulation in Man Residing in Mumbai City and their Impact on general Health

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Abstract

Toxic effect of heavy metals is gradual and long lasting. An attempt is made to study the heavy metals accumulated in the nails of man living in thickly populated Mumbai city. The results of the qualitative analysis of finger nails for metals Cd, Pb, Cr, Mn, Fe, Ni, Cu, and Zn were recorded according to the questionnaires made on the male subjects. Higher concentrations of Cr, Fe, Cd, Pb and Ni clearly explains the environmental contamination and its out coming effects in man. Continuous investigation has been made to collect the data regarding the environmental factors on man. The present study gives the concentration of heavy metal accumulated in man due to chronic exposure to environmental pollution, using nail as diagnostic tool and its relationship with health.

Introduction

Pollution can be thought of as being the presence of too high a concentration of a resource in the wrong place at a wrong time. This emphasize that pollution involves the misuse of resources. What may be correct for one system may not be correct for a different system. The native fluxes in all elements follow a cyclic path through the same major reservoirs. The difference between the size of fluxes and the amount in the reservoirs reflect both chemical properties of the elements and the quantities of the elements, actually present in the inner surface of the earth. Human activities have increased a number of fluxes associated with natural cycle, especially in the pathway that led from the land based, to the ocean based reservoirs.

It is always to be remembered that, the chemical form of the element modifies its usefulness to organisms but, they are useless in their elemental form and highly toxic if combined. It is therefore an over simplification that, certain elements are essential and other elements are toxic. The elements must be in an available form for it to interact with an organism.

Living organisms in earth are surrounded by an environment which contains more inorganic than organic molecules, and life essentially is a manifestation of inorganic elements. Metals enter our body through drinking water, drug, food, skin and air contaminants. All have metabolic mechanisms for the utilization of elements which are found in relatively high abundance in our environment. The toxic metal ions are retained in our body for a long period of time with less chance of biological inactivation and as such they produce harmful effect in our body. Toxic action of metal ions occurs at cellular or sub cellular level. More toxic is the metal ion if the electro negativity of the metal ion is high. The toxicity could be due to blocking of the essential biological active site of bio molecules. Cd (II) forms much stronger bond with enzyme than Zn(II) . It blocks the enzyme activity of ADP, ATP, alcohol dehydrogenase, amylase, carbonic anhydrase and carboxypeptidase. Binding of metal ion with polynucleotide can cause congenital deformation and cancer. Nature has developed its own detoxification mechanism for the removal of toxic metal ion from the body.

Analysis of finger nails and hair has been useful in the study of trace metals accumulated in the body. Since these tissues are devitalized and have low metabolic turn, their analysis may reflect metals accumulated as a result of chronic exposure[1]. It has been found by atomic absorption spectral studies that,

after minutes of arsenic poisoning, arsenic are accumulated in hair[2]. Greying of hair is believed to be due to the replacement of Mg in hair by Ni(II) and accumulation of Ni (II) in our hair. Thus it is very important to determine the metal concentrations in humans to monitor and assess their impact on human health [3] [4] [5] [6].Among various biopsy materials blood, hair, nail, teeth and other body fluids may be used as bio indicator for this purpose. Unlike blood that gives transient concentration, nails can provide the continuous record of trace element concentration of the body, they can be easy sampled and analyzed for the metals accumulated and the essential metals in the tissue[7].Studies on nails as bio-indicators are very few[8]. Studies on co-relation of metal levels with different parameters using nail is scarce. The aim of the present study is to detect the heavy metals accumulated in the nail of man residing in highly polluted Mumbai city of India .For the purpose of this study finger nails of male subjects of two different groups (25-35 years, 36-50 years)were used as biopsy material. Male subjects of same age are used as control and are selected on the basis of food habits, medical history record and personal habits like alcoholic , smoking. Subjects were personally interviewed and questionnaires are filled in detail about their personal and medical history.

Material and Methods

Nail samples were collected after washing their hands thoroughly with distilled water & medicated soap. Hands were wiped with sterile towel in order to prevent external contamination. Nails were cut using standard stainless steel scissors. Finger nail samples of male subjects of age group 25 – 50 years residing in Mumbai for more than 10 – 25 years were collected. For the purpose of this study finger nails of male subjects of two different age groups (25-35 years, 36-50 years) were used as biopsy material. Each nail sample was washed dried and sealed in plastic cover.

For analysis these nail samples were weighed, digested and converted into water clear solution. Personal history and medical records were studied in detail through questionnaire based on recommendation of World Health Organization (WHO). Information regarding sex, age, feeding habits, personal habits like smoking, drinking, and place of residence occupation were recorded.[9],[10]. Male subjects of same age are used as control and are selected on the basis of food habits, medical history record and personal habits like alcoholic, smoking. Subjects were personally interviewed and questionnaires were filled.

For washing of nail samples standard procedure for washing was followed [7]. The nails were soaked in acetone to remove contamination, rinsed with distilled water, dried in oven and stored in desiccators.

The dried nails were digested with 10 ml of 6:1 mixture of concentration nitric acid and perchloric acid, kept overnight at room temperature to prevent excessive foaming and heating at 160°C. The mixture was clear and less than 1ml of solution remained. Organic matter was destroyed by wet acid digestion. Each sample was diluted to 0.1N nitric acid. The concentrations of metals were arranged by using Perkin Elmer AAS model 250 with air acetylene flame. A series of standards were prepared in de-ionized water for instrument calibration by diluting commercial standard containers 1000 ppm of the metals. All reagents used were of analytical grade Merck (Germany) free from metal contamination. Blanks were prepared to reduce errors. Instrumental parameters like bandwidth, lamp current, wave length for estimation of metals by atomic absorption spectrophotometer were set up separately for each metal. The values of metals were recorded as arithmetic mean in μg/g with standard deviation. Statistical significance of mean value between different groups was determined by Student's't' test.

Results and Discussion

The results of the quantitative analysis of finger nails for metals Cd, Cr, Cu, Fe, Mg, Ni, Pb, and Zn were recorded according to the habits like smoking, drinking, vegetarian and non-vegetarian (Tables 1 and 2). Medical history of the subjects was also studied (Tables 3 and 4). Continuous investigations have been made to collect data regarding the concentration of heavy metal accumulated in man.

Cr plays an important role in skin disorder [11], [12].High level of chromium (Cr) was detected in subjects smoking tobacco and diabetic subjects. Besides tobacco, metals are present in wrappers. Chromium contents in tobacco leaves could also be due to their intake of heavy metal from soil. In this study, the effect of inhaling smoke emitted by smokers on the subjects present nearby was ignored. Increase in level of chromium has been correlated with cancer, growth and depression [12].

High level of Fe which was noted in the present study could be due to iron oxide fumes in the environment. High content of Fe was noted in smokers, non-vegetarian, liquor users, skin diseased, and subjects suffering from ophthalmic disease, asthma, mental stress, blood pressure and diabetes.

One possible way of high copper level observed in smokers and vegetarians could be due to the over use of pesticides and its entry into tobacco plants and soil.

Nickel metal is carcinogenic [13],[14]. It is a well known metal responsible for cancer, depression and hemorrhage . Significant Ni levels were noted in smokers compared to non-smokers. High levels of Ni observed can cause health complications in man. Elevated value of nickel revealed in diabetic and mental stress subjects needs further investigation.

Cd levels in the subjects studied were comparatively at higher level, could be due to high exposure to pesticide and environmental exposure. Cadmium is very toxic [15],[16].. Nails of non vegetarian subjects showed high amount of cadmium. Toxic effects of cadmium has received wide spread attention. The main target organs for cadmium are kidney and liver with critical effects when the concentration of 200μg/g Cd is reached in kidney cortex [17],[18]. The body burden of cadmium increases with age as the half-life in the body is about 20 – 30 years. Higher Cd level were observed in the nail of male subjects with high blood pressure and mental stress. These subjects also had symptoms of chest pain where further investigation is necessary.

Zn is an essential component of about a hundred enzymes in total, though the number of Zn containing enzymes on vertebrates is much smaller [19]. Zinc concentrations in the present study were high in vegetarians, mental stress and tuberculosis subjects. More detailed investigations are required for clarification. Zinc deficiency leads to dwarfism, reduced rate of blood clotting, and wound healing, skin abnormalities and other problems [19][20].

Pb enters the body through air, water, food and cannot be removed by washing fruits and vegetables .It is serious cumulative body poison. Concentration of Pb in the nail sample was considerably high in non vegetarians, mental stress and chest pain subjects showing that it was due to environmental influence [21].

There was no trace of metal in liquor users which shows that liquor is not a contributing factor to metal accumulation. There is a significant co-relation between skin disease and metal accumulation [5]. In the present study concentrations of Cr, Mn, Fe and Cu were high in diabetic subjects. High blood pressure subjects showed high content of Cd, Mn and Cu.. TB subjects showed very high level of Zn content. Cd, Pb, Mn, Ni, Cu, Zn contents were very high among mental stress subjects.

Cd, Mn and Cu are metals related to high blood pressure subjects [22],[23]. Ni level was high among skin allergic subjects. Present experimental observation also showed high level of Cd in hyper tension subjects not exposed to occupation hazard.
Male subjects with chronic headache and uneasiness showed high level of Cr, Pb and Mn in their nail. Workers working in fireworks factories showed high content of Pb in their nails [24]. High Magnesium level was observed in neurological disorder subjects..
High lead exposed subjects also showed symptoms of heart ailment. Lead causes high blood pressure and it relatively attack on specific sites and cellular elements of nervous system [25].No correlations of metals were seen in Hepatitis B subjects. High accumulation of toxic metal could also be due to intake of drugs by patients[26],[27]. where further investigation is necessary.

Toxic elements plays vital role in human health[28]. More investigation is required to know about the safe range of each element. In the present study the significant levels of these elements in nail samples, clearly indicate the presence of metals in the environment and their toxic nature in case of chronic exposure.

The present investigation reveals with the co-relationship of metals accumulated in male subjects due to environmental pollution using nail as diagnostic tool, but still more studies are essential to enhance the merit of investigation and application of it in forensic and medical studies. Present study can be used for preparation of standard reference material of nail by adopting quality control measures to enhance the reliability of results. The study clearly states that nail can be used as bio-indicator for diagnosing the extent of metal toxicity.

Table 1. Concentrations of studied elements in nail samples from first age group according personal habits

No.	Type of sample	No. of sample	Age	Cd µg/g	Pb µg/g	Cr µg/g	Mn µg/g	Fe µg/g	Ni µg/g	Cu µg/g	Zn µg/g
1.	Smokers	25	25 – 35 Years	0.75 ± .62	56.83 ±20.27	105.6 ± 39	11.80 ± 9	451.0 ± 69	69.3 ± 17	4.13 ± 1.4	168.4 ± 33
2.	Non Smokers	25		0.91 ±0.52	17.0 ± 3.8	83.00 ± 26	18.75 ± 5.0	280.6 ±43.9	55.3 ± 13	8.53 ± 3.2	100.23 ± 4.2
3.	Vegetarian	20		0.8 ± 0.2	16.3 ± 1.5	69.5 ±17.2	28.5 ±3.2	337.3 ±38.2	63.3 ± 1.7	9.63 ± 3.5	187.96 ± 46.4
4.	Non vegetarian	25		1.0 ± 0.2	14.4 ± 4.8	90.2 ±11.2	40.7 ± 1.3	363.2 ±76.8	75.73 ±14.8	7.10 ± 3.5	161.26 ± 36.5
5.	Liquor Users	20		2.1 ± 0.9	34.6 ± 8.9	87.2 ±21.1	19.3 ± 8.3	313.8 ± 3.5	62.5 ±17.3	11.18 ± 5.4	187.72 ± 96.3
6.	Liquor Non Users	20		0.87 ± 0.4	18.61 ± 8.5	73.5 ±18.2	16.3 ± 7.6	289.6 ± 4.5	61.2 ± 3.6	8.4 ± 4.2	110.4 ± 56.5
7.	Control	25		0.9 ± 0.3	20.3 ± 7.6	86.4 ±10.1	10.0 ± 5.2	286.5 ±63.6	56.3 ± 2.9	7.63 ± 3.6	180.5 ± 32.8

± = SD P < 0.05

Table 2. Concentrations of studied elements in nail samples from second age group according personal habits

No.	Type of sample	No. of sample	Age	Cd µg/g	Pb µg/g	Cr µg/g	Mn µg/g	Fe µg/g	Ni µg/g	Cu µg/g	Zn µg/g
1.	Smokers	25	36 – 50 Years	1.30 ± 0.7	93.7 ±11.3	156.1 ±70.3	15.8 ± 9.2	317.6 ± 46.3	93.2 ±11.2	26.0 ± 9.2	173.3 ±62.8
2.	Non Smokers	20		0.68 ± 0.2	30.12 ± 5.4	93.5 ±11.3	18.8 ±10.3	274.15 ± 82.3	62.5 ±31.3	10.4 ± 4.2	162.5 ±58.2
3.	Vegetarian	20		0.80 ±0.31	16.45 ± 4.8	68.40 ±16.4	28.5 ± 7.6	347.30 ± 34.2	63.4 ±15.2	9.3 ± 1.9	178.9 ±14.4
4.	Non vegetarian	20		1.88 ± 0.8	22.7 ± 9.8	86.9 ±20.1	13.2 ± 9.8	314.3 ± 72.3	83.4 ±22.2	6.5 ± 7.5	181.3 ±43.2
5.	Liquor Users	25		1.13 ± 0.8	20.25 ± 7.3	84.9 ±23.2	18.5 ± 9.3	320.2 ± 93.2	80.2 ±22.3	6.5 ± 3.2	158.0 ±76.2
6.	Liquor Non Users	20		0.91 ± 0.2	23.9 ± 8.3	101.9 ±61.2	16.2 ±10.3	255.6 ±110.2	72.3 ±20.3	9.1 ± 1.1	157.5 ±39.3
7.	Control	25		1.78 ± 0.9	22.0 ± 9.2	86.0 ±33.3	13.0 ± 8.0	292.3 ± 83.4	58.3 ±20.1	7.5 ± 4.5	180.5 ±60.2

Table 3. Concentrations of studied elements in nail samples from first age group according medical history

o.	Type of sample	No. of sample	Age	Cd µg/g	Pb µg/g	Cr µg/g	Mn µg/g	Fe µg/g	Ni µg/g	Cu µg/g	Zn µg/g
1.	Skin disease	20	25 – 35 Years	1.08 ± 0.8	19.0 ±7.2	165.5 ±28.3	24.6 ±3.7	361.22 ±40.6	57.04 ±6.2	11.43 ±8.3	183.03 ±63.08
2.	Hypertension	20		1.30 ± 0.8	16.80 ±9.3	81.14 ±28.7	18.4 ± 5.7	309.13 ±47.3	39.4 ±10.4	17.0 ±9.8	154.12 ±58.7
3.	Hypotension	25		1.02 ± 0.9	20.03 ±10.4	91.3 ±19.6	12.94 ±6.5	303.5 ±52.3	56.8 ±17.2	10.72 ±4.3	200.85 ±41.7
4.	Diabetes	25		0.98 ±0.75	14.2 ±10.1	170.8 ±46.5	24.6 ±12.3	295.7 ±71.4	105.9 ±37.3	7.72 ± 3.2	179.27 ± 39.5
5.	Asthma	20		1.5 ±0.51	16.9 ±9.7	178.9 ±37.8	33.5 ±13.3	578.5 ±61.3	128.0 ±47.3	7.85 ±1.4	246.9 ±27.8
6.	TB	12		0.71 ± 0.1	25.0 ±5.8	78.2 ±12.8	11.80 ±4.3	300.5 ±50.8	48.3 ±10.5	5.82 ±2.3	250.9 ±22.11
7.	Mental Stress	12		2.0	37.9	100.5	17.82	308.7	83.5	18.87	288.7

				± 0.2	±6.1	±20.3	±3.6	±40.7	±20.6	± 3.5	± 35.7
8.	Control	25		0.99 ±0.22	20.0 ±5.17	85.6 ±23.6	10.0 ±1.09	285.6 ±10.4	56.24 ±10.4	7.63 ±2.4	180.6 ±43.1

± = SD P < 0.05

Table 4. Concentrations of studied elements in nail samples from second age group according medical history

No.	Type of sample	No. of sample	Age	Cd µg/g	Pb µg/g	Cr µg/g	Mn µg/g	Fe µg/g	Ni µg/g	Cu µg/g	Zn µg/g
1.	Skin disease	25	36 – 50 Years	1.0 ±0.2	17.2 ± 9.6	197.8 ± 53.2	33.20 ± 9.2	381.0 ± 43	59.4 ± 12.0	23.0 ±11.2	148.9 ± 92.3
2.	Hypertension	25		1.0 ±0.3	8.8 ± 2.5	80.5 ± 26.2	24.8 ± 9.9	328.3 ±61.0	19.5 ± 9.2	28.7 ± 7.8	138.7 ± 76.2
3.	Hypotension	25		1.50 ±0.5	28.03 ±10.7	110.3 ± 18.7	14.9 ± 7.2	310.5 ±43.2	57.5 ± 22.3	14.7 ± 4.8	210.95 ± 32.3
4.	Diabetes	25		1.8 ±0.7	29.3 ±11.2	190.8 ± 28.2	44.6 ± 18.2	300.7 ±62.3	110.5 ± 71.3	8.02 ± 3.2	170.3 ± 22.3
5.	Asthma	20		6.9 ±1.7	18.2 ±12.8	193.2 ± 33.2	848.5 ± 20.2	698.3 ±73.4	149.85 ± 41.2	9.85 ± 4.2	290.7 ± 32.4
6.	TB	12		0.8 ±0.2	26.5 ±13.2	61.7 ± 22.2	9.8 ± 1.5	361.7 ±41.3	47.8 ± 9.3	4.8 ± 1.8	266.2 ± 92.3
7.	Mental Stress	12		1.8 ±0.3	36.9 ±14.2	98.7 ± 13.0	16.8 ± 2.3	300.7 ±33.2	78.2 ± 12.2	16.8 ± 6.2	246.17 ± 71.3
8.	Control	20		1.03 ±0.2	35.23 ±11.2	116.24 ± 73.2	17.9 ±10.22	356.9 ±68.0	84.95 ± 31.5	6.14 ± 3.2	174.33 ± 68.3

Conclusion

Toxic metals play vital role in human health. Yet there is obviously a great deal of concern about safe range of each element. There is no previous report on heavy metal accumulation study on human finger nail residing in Mumbai city. More investigation is required so that necessary quality control measures can be taken. Present study clearly state that finger nail can be used as diagnosing tool for recording the extent of pollution in urban areas.

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