Annex 4

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WORKPLACE AND OCCUPATIONAL HEALTH: THE FIRST METAL EVALUATION USING NUCLEAR AND ANALYTICAL TECHNIQUES IN THE STATE OF MINAS GERAIS - BRAZIL

Centro de Desenvolvimento da Tecnologia Nuclear (CDTN)
Comissão Nacional de Energia Nuclear (CNEN)

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CO-ORDINATED RESEARCH PROGRAMME
ASSESSMENT OF LEVELS AND HEALTH-EFFECTS OF AIRBORNE PARTICULATE MATTER IN MINING, METAL REFINING AND METAL WORKING INDUSTRIES USING NUCLEAR AND RELATED ANALYTICAL TECHNIQUES

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1. ABSTRACT

Belo Horizonte, the capital of the State of Minas Gerais and its neighbourhood are the second industrial center of Brazil, concentrating many industries in several areas mainly metal refining and transformation. There are no registers about the level of metal concentration in the environmental air in the industry, nor even of the level of workers' contamination. The overall objective of this Project is to make a survey of the exposures to metals related to occupational diseases in galvanizing industry, which is responsible for the majority of occurrences of occupational diseases. The survey will be accomplished using as bioindicators hair, nails, blood, urine, and individual air filters. These matrixes

will indicate the incorporation of metals and the exposure level. The analytical techniques that will be applied are the neutron activation joined to related non nuclear analytical techniques, such as atomic absorption.

2. INTRODUCTION

The industrial processes introduce the contamination risks to the workers all the time. The easiest ones to be identified are those that kill or mutilate. Other processes take time to produce the sinister effects, because of that the contamination is difficult to be identified.

There are around 15000 chemical and physical toxic agents commonly used in industries but there are only some legal rules of exposition to 500 of them. Thus the effects throughout the years and the biggest part of these effects hasn't been demonstrated. It is important to say that every day, with more modern processes, new chemical agents appear enlarging the list of pollutants. The effects of these pollutants are unknown.

In Brazil the statistical surveys about professional diseases refer to the accidents and damages and not to the occupational diseases developed through long exposures to unhealthy conditions of work, with physical risk and toxic chemical substances. The many cases of occupational diseases that are computed are those that were reached in extremely dangerous conditions or damages. The workplace exposures are computed when the acquisition of disease is obvious or probable, that is, dangerous diseases easily identified. But the great part of workers is exposed to low levels that can be lethal in a long period of time, because these expositions may cause chronic infirmities. Most of the times the outset of the diseases is not noticed and the appearing of a pulmonary cancer or heart diseases is attributed to non-occupational causes by the industry, by the medical group. Then these diseases are not computed.

Among the toxic substances, the metals are detached because many of them are already present on the work environment and may cause since allergies until cancer and many dangerous intoxications. The Law nº 24 (29th December, 1994) from the Secretaria de Segurança e Saúde no Trabalho (Security and Health at Work Secretary) approved the NR-7 Program of Medical Control of Occupational Health, in what the Maximum Biological Levels Allowed and the Values of Normality References are previewed. Concerning metal and toxic inorganics only the arsenic, chromium, cadmium, lead and mercury values are previewed. Manganese, for instance, that is not mentioned, presents a biological half-life of 37 days, being the bones and the brain the slowest places of removing. One of the consequences of its accumulation in the body is the muscular hypertonie of the face and of inferior limbs. Other metals are not mentioned either.

Biological monitors of exposure assess the health risk through the evaluation of the level of incorporation or exposure. The biological materials more frequently used for the monitoring of metals are blood, urine, hair, nails, expired air, faeces, milk, and others.

This Project will be developed at CDTN (Centro de Desenvolvimento da Tecnologia Nuclear) and partners: FUNED (Fundação Ezequiel Dias), CST/SMSa (Secretaria Municipal de Saúde de Belo Horizonte) and FUNDACENTRO/BH.

In CDTN a broad spectrum of nuclear and non-nuclear technical activities were conducted, related to the fields of ore prospecting, petrography, mineral processing, chemical processes, uranium enrichment, material testing, fuel element development, waste management, fuel reprocessing, reactor physics, accident analysis, reactor commissioning, thermal-hydraulic testing, electric-mechanical systems design, environmental engineering, radiation protection, licensing, irradiation, radioisotope application, chemical analysis, mechanical systems construction, electronics, instrumentation development, nuclear measurements, computing, data processing, documentation and education.

The facilities occupy around 25,000 square meters located on a tract nearly 200,000 square meters, where about 400 employees are presently at work. As far main irradiating apparatus are concerned the facility a $7x10^3$ MBq irradiator of ^{60}Co, a natural uranium metal fuelled light water moderated sub-critical assembly and the TRIGA MARK I reactor. There is a strong and mutually profitable co-operation with national and foreign nuclear centers, universities, institutions, associations and industries. Through the years CDTN has been determining chemical elements in many different matrixes including air filters and biological materials through the technique of neutron activation (NAA) (parametric analyses k_o- standard method and non-parametrical) involving or not chemical and/or radiochemical separations using the rotary specimen rack of the TRIGA MARK I IPR R1. Analytical techniques such as atomic absorption (AA), visible ultraviolet (UV-VIS), gas chromatography (GC), x-ray (XR), HPLC and others, constitute an available instrumental group monitored by an expert staff.

The Fundação Ezequiel Dias/FUNED (Ezequiel Dias Foundation) is a public state organization involving several institutes. In the Octavio Magalhães Institute there is the Divisão de Bromatologia e Toxicologia (Division of Toxicology) responsible for the food and the biological materials analysis.

The Coordenação de Saúde do Trabalhador/CST/SMSa (Worker Health's Co-ordination) is an sector in Secretaria Municipal de Saúde de Belo Horizonte (Municipal Health Secretary). It's responsible for planning and co-ordination of the worker's health policies in the city of Belo Horizonte. This sector works with social assistance (the workers who have occupational diseases are cared by a team including physicians, social assistants, nurses, physiotherapists, and receive complete treatment) and workplace's surveillance, which means the investigation of the workplace's hazard and the implementation of control measures.

The FUNDACENTRO/BH is linked to Administração Pública Federal-Ministério do Trabalho (Federal Administration-Work's Ministry). The main tasks of this department are to develop researches and to give instructions in the work scope and the relations with health and security.

This Project is inserted in the work/studies developed by CDTN, FUNED, CST/SMSa and FUNDACENTRO/BH. It has been developing some studies about the monitoring of working places and occupational diseases, such as the evaluation of risky factors associated to the exposures to lead in battery reformer places by CDTN, FUNED, CST/SMSa and FUNDACENTRO/BH, having other partner, the Secretaria Municipal de Saúde de Contagem (Municipal Health Secretary of Contagem).

On the other hand, the CDTN, among its objectives, has been giving priority to the projects about the environment and health:

- "Study of the sorption of caesium in the soil" (funded by Conselho Nacional de Pesquisa/CNPQ - National Research Council),

- "Physical and mathematical modelling of contaminant transport in aquifers" (funded by IAEA),

- "Study of contamination by mercury in manual gold mines in Minas Gerais: its impact on health and on environment" (partnership: CDTN, Fundação Estadual do Meio-Ambiente/FEAM - Environmental Foundation of State of Minas Gerais, Fundação Nacional de Saúde/FNS - Health Nacional Foundation),

- "Study of parameters related to the quality of the water consumed by the population of 56 cities of the State of Minas Gerais - Brazil" (was presented to IAEA in 1993; partnership: CDTN, Fundação Estadual do Meio-Ambiente/FEAM - Environmental Foundation of State of Minas Gerais, Fundação Nacional de Saúde/FNS - Health National Foundation),

- "Mercury in manual gold mines" (partnership: CDTN - FEAM - Secretaria Estadual de Saúde/SES - Health Secretary of State of Minas Gerais).

Relating environmental analysis, CDTN has been managing and executing Environmental Monitoring Programs involving mining, industries and nuclear facilities. The Institute has around of 4500 dosimeters films users per month in 270 institutions (hospitals, industries, research institutes), distributed all over the Country.

3. OBJECTIVE

The overall objective of this Project is to make a survey of the exposures to metals related to occupational diseases in galvanizing industry using as bioindicators, hair, nails, blood, urine, and individual air filters. These matrixes will indicate the incorporation of metals and the exposure level. Besides arsenic, chromium, cadmium, lead and mercury, also zinc, aluminium, tin, nickel, copper, cobalt, manganese and vanadium will be determined if present in the samples.

This Project will be the first evaluation of metals in occupational environment in the State of Minas Gerais, determining the elements in bioindicators and personal filters using nuclear and related analytical techniques.

4. STUDY AREA

Belo Horizonte, the capital of the State of Minas Gerais and its neighbourhood are the second industrial center of Brazil, concentrating many industries in several areas: metallurgy of iron, textile, automotive, refractory-materials, ink, food, mining, ceramics and cement plant. Considering the hazards involving chemical elements, metals predominate the health's problems in worker of different

plants. But there are no registers about the level of metal concentration in the environmental air in industry, nor even of the level of workers' contamination.

Besides those works there are around 30 galvanization industries from those called home industries to modern ones in Belo Horizonte. Many of them are in the commercial center of the city and this kind of industry is responsible for the majority of metal contamination occurrences.

Galvanizing industry is an electroplating process where the process of depositing a coating having a desirable form is by means of electrolysis. Its purpose is generally to alter the characteristics of a surface so as to provide improved appearance, ability to withstand corrosive agents, resistance to abrasion, or other desired properties or a combination of them although occasionally it is used simply to alter dimensions.

Electrolysis is carried out in a bath which may consist of fused salts or solutions of various kinds; in commercial practice it is almost invariably a water solution.

In general the steps in galvanization are: polishing using abrasives, washing with acids and sodium hydroxide and electrodeposition involving deposits of aluminium, cadmium, chromium, cobalt, copper, gold, indium, iron, lead, nickel, platinum, silver, tin and zinc.

Because of the variety of metals used in galvanizing process the four institutions, CDTN, FUNED, CST/SMSa and FUNDACENTRO/BH, as partners, will examine which metals are more critical in terms of exposure.

5. EXECUTION

The sampling of the workers´ biomaterials will be carry out by the institutions. The control group, formed by people that aren't exposed to the same environmental that the workers, will be selected and the institutions will collect the samples.

The analysis of the reference materials and the bioindicators and personal air filters samples from the workers and the control group will be performed by CDTN and FUNED. The techniques that will be used are NAA, XR, that will be executed by CDTN and other techniques such as AA, HPLC, UV-VIS, GC that will be executed joined with CDTN and FUNED whenever necessary.

The results will be evaluated by CDTN, FUNED, CST/SMSa and FUNDACENTRO/BH considering the physicochemical properties of metals, ventilation parameters and permissible levels in biological media, biological limit values or biological versus exposures values. Under medical point of view solutions will be suggested.

6. PRELIMINARY RESULTS

Some preliminary results are in TABLE I and II. The samples are hair and nails from the 9 workers of a small industry in the center of Belo Horizonte: 3 officers, 2 bath operator, 1 metal piece washer and 3 polishers.

The hair and nails samples were irradiated without washing for 5 min to detect the short life nuclides. It was applied the neutron activation, k_0 parametric neutron activation analysis method. The objective of analysing without washing was to verify the level of exposition. Quality control was done using replicates of samples and the certificate reference material Human Hair (GBW 09101), from Shanghai Institute of Nuclear Research Academia Sinica.

In TABLE I are the concentrations determined in the hair samples and in TABLE II are the concentrations found in the nails. The results are in function of the occupation of the worker. It wasn't possible, during the sampling, to collect hair and nails from everybody because of several problems: one was bald, the other one had cut the nails the day before, and so on. It's possible to observe that the concentrations determined in workers samples are higher than in reference material.

TABLE I – CONCENTRATIONS OF ELEMENTS IN HAIR (H)

($\mu g\ g^{-1}$)

	Al	Cl	Cu	I	Mn	Na	Ti	V
Officer 1	485 ± 27	1157 ± 150	68 ± 33	5 ± 2	9 ± 4	758 ± 106	*	*
Zn bath operator	644 ± 45	1786 ± 387	116 ± 35	*	*	562 ± 122	*	*
Cr, Cu and Ni bath operator	134 ± 12	942 ± 87	82 ± 22	*	5 ± 3	880 ± 67	*	*
Piece washer	450 ± 20	728 ± 90	140 ± 23	*	6 ± 3	478 ± 58	*	*
Polisher 1	3417 ± 67	1930 ± 200	400 ± 60	*	22 ± 6	625 ± 100	84 ± 40	2.1 ± 0.8
Polisher 3	538 ± 28	307 ± 80	132 ± 30	*	12 ± 3	610 ± 78	*	*
HH (experimental)	14 ± 7	157 ± 50	19 ± 18	*	4 ± 2	269 ± 48	*	*
HH (certificated)	13.3 ± 2.3	152**	23 ± 1.4	0.875**	2.94 ± .20	266 ± 12	-	0.069**

*not detected

** information values

TABLE II – CONCENTRATIONS OF ELEMENTS IN NAILS (N)

($\mu g\ g^{-1}$)

	Al	Cl	Cu	I	Mn	Na	Ti	V
Zn bath operator	776 ± 100	457 ± 290	188 ± 96	*	*	1146 ± 258	*	*
Cr, Cu and Ni bath operator	1540 ± 200	3420 ± 450	1210 ± 135	17 ± 8	14 ± 1	1390 ± 340	*	*
Polisher 1	16500 ± 200	8770 ± 880	990 ± 200	*	99 ± 20	2100 ± 500	210 ± 170	10 ± 4
Polisher 2	660 ± 190	9130 ± 700	1040 ± 180	*	*	1830 ± 380	*	2 ± 3
Officer 2	275 ± 100	2215 ± 650	*	*	*	610 ± 380	*	*

*not detected

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