



Vanadium Health Research Programme: Recent Published Literature

October - December 2016

**This document is a report by IEH Consulting Ltd. for the
Vanadium International Technical Committee (VANITEC).**

Prepared by: Ruth Bevan and Lini Ashdown
Reviewed by: Len Levy
4th January 2017

Introduction

This report presents the bibliographic details of papers identified as being published during the period October 2016 – December 2016.

The papers were selected because they address research areas that are considered of direct relevance to the health and environmental effects of Vanadium. In order to aid review, the papers are presented under the following categories; it should be noted however, that when considered appropriate, some papers may appear in more than one section.

Section 1 – HUMAN EXPOSURE MEASUREMENT AND MODELLING: Papers relating to the measurement or modelling of environmental and occupational Vanadium exposure; the development of human biomarkers of exposure or effect.

Section 2 - HEALTH EFFECTS: Papers on the influence of Vanadium on health, disease and dysfunction; assessment of the influence of genetic and epigenetic factors on human susceptibility to the effects of Vanadium; development and implementation of new medical approaches to the treatment of excessive Vanadium exposure.

Section 3 – BIOLOGICAL MECHANISMS: Papers on the biochemical and toxicological mechanisms underlying the effects of Vanadium.

Section 4 – USES OF VANADIUM: Papers relating to the use of Vanadium in medical and dental devices, dietary supplements and as therapeutic agents.

Section 5 – ENVIRONMENTAL EFFECTS in PLANTS and SOIL: Papers relating to the effects following environmental exposure to Vanadium that are specific to plants and soil.

Section 6 – ENVIRONMENTAL EFFECTS in TERRESTRIAL ORGANISMS: Papers relating to the effects following environmental exposure to Vanadium that are specific to terrestrial organisms.

Section 7 – ENVIRONMENTAL EFFECTS in AQUATIC ORGANISMS: Papers relating to the effects following environmental exposure to Vanadium that are specific to aquatic organisms.

Section 8 – MISCELLANEOUS: Other papers considered of general interest or potential relevance to the study of the health effects of Vanadium that do not relate to the above categories.

1. HUMAN EXPOSURE MEASUREMENT AND MODELLING

Annangi, B., Bonassi, S., Marcos, R., et al. (2016) Biomonitoring of humans exposed to arsenic, chromium, nickel, vanadium, and complex mixtures of metals by using the micronucleus test in lymphocytes. *Mutation Research/Reviews in Mutation Research*, Available

at:

https://www.researchgate.net/profile/Dr_Balasubramanyam_Annangi/publication/296472618_Biomonitoring_of_humans_exposed_to_arsenic_chromium_nickel_vanadium_and_complex_mixtures_of_metals_by_using_the_micronucleus_test_in_lymphocytes/links/56e2abf308aebc9edb1b946a.pdf

Abstract:

Various metals have demonstrated genotoxic and carcinogenic potential via different mechanisms. Until now, biomonitoring and epidemiological studies have been carried out to assess the genotoxic risk to exposed human populations. In this sense, the use of the micronucleus assay in peripheral blood lymphocytes has proven to be a useful tool to determine increased levels of DNA damage, as a surrogate biomarker of cancer risk. Here we review those biomonitoring studies focused on people exposed to arsenic, chromium, nickel, vanadium and complex mixtures of metals. Only those studies that used the frequency of micronuclei in binucleated (BNMN) cells have been taken into consideration, although the inclusion of other biomarkers of exposure and genotoxicity are also reflected and discussed. Regarding arsenic, most of the occupational and environmental biomonitoring studies find an increase in BNMN among the exposed individuals. Thus, it seems conclusive that arsenic exposure increases the risk of exposed human populations. However, a lack of correlation between the level of exposure and the increase in BNMN is also common, and a limited number of studies evaluated the genotype as a risk modulator. As for chromium, a BNMN increase in occupationally exposed subjects and a correlation between level of exposure and effect is found consistently in the available literature. However, the quality score of the studies is only medium-low. On the other hand, the studies evaluating nickel and vanadium are scarce and lacks a correct characterization of the individual exposure, which difficult the building of clear conclusions. Finally, several studies with medium-high quality scores evaluated a more realistic scenario of exposure which takes into account a mixture of metals. Among them, those which correctly characterized and measured the exposure were able to find association with the level of BNMN. Also, several genes associated with DNA damage repair such as OGG1 and XRCC1 were found to influence the exposure effect.

Le Bot, B., Lucas, J.-., Lacroix, F., et al. (2016) Exposure of children to metals via tap water ingestion at home: Contamination and exposure data from a nationwide survey in France. *Environment International*, 94: 500-507.

Abstract:

29 inorganic compounds (Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, Gd, K, Mg, Mn, Mo, Na, Nd, Ni, Pb, Sb, Se, Sr, Tl, U, V and Zn) were measured in the tap water of 484

representative homes of children aged 6 months to 6 years in metropolitan France in 2008–2009. Parents were asked whether their children consumed tap water. Sampling design and sampling weights were taken into account to estimate element concentrations in tap water supplied to the 3,581,991 homes of 4,923,058 children aged 6 months to 6 years. Median and 95th percentiles of concentrations in tap water were in µg/L: Al: < 10, 48.3, As: 0.2, 2.1; B: < 100, 100; Ba: 30.7, 149.4; Ca: 85,000, 121,700; Cd: < 0.5, < 0.5; Ce: < 0.5, < 0.5; Co: < 0.5, 0.8; Cr: < 5, < 5; Cu: 70, 720; K: 2210, 6740; Fe: < 20, 46; Mn: < 5, < 5; Mo: < 0.5, 1.5; Na: 14,500, 66,800; Ni: < 2, 10.2; Mg: 6500, 21,200; Pb: < 1, 5.4; Sb: < 0.5, < 0.5; Se: < 1, 6.7; Sr: 256.9, 1004; Tl: < 0.5, < 0.5; U: < 0.5, 2.4; V: < 1, 1; Zn: 53, 208. Of the 2,977,123 young children drinking tap water in France, some were drinking water having concentrations above the 2011 World Health Organization drinking-water quality guidelines: respectively 498 (CI 95%: 0–1484) over 700 µg/L of Ba; 121,581 (CI 95%: 7091–236,070) over 50 mg/L of Na; 2044 (CI 95%: 0–6132) over 70 µg/L of Ni, and 78,466 (17,171–139,761) over 10 µg/L of Pb. Since it is representative, this tap water contamination data can be used for integrated exposure assessment, in conjunction with diet and environmental (dust and soil) exposure data. © 2016 Elsevier Ltd.

Suliburska, J., Kocylowski, R., Komorowicz, I., et al. (2016) Concentrations of Mineral in Amniotic Fluid and Their Relations to Selected Maternal and Fetal Parameters. *Biological Trace Element Research*, 172(1): 37-45.

Abstract:

The concentrations of various trace elements in amniotic fluid (AF) change over the course of pregnancy, with gestational age and fetus growth. The aim of the present study was to evaluate the concentrations of selected essential and toxic elements in AF and their relations to maternal and fetal parameters. The study was carried out in 39 pregnant women, aged 34.6 ± 4.7 years, between weeks 16 and 26 of gestation. Amniotic fluid samples were obtained during the standard procedure of amniocentesis in high-risk patients for chromosomal abnormalities. An inductively coupled plasma mass spectrometry (ICP-MS) technique was used to determine the levels of Al, As, Ba, Cd, Co, Cr, Cu, Mg, Mn, Ni, Sr, U, and V in AF. Body mass and blood pressure were measured in all the women. The basic parameters of fetal development were also assayed. It was found that the age of the mother, the gender of the fetus, and the week of the pregnancy may affect the concentrations of mineral in the amniotic fluid. Moreover, several significant correlations between the essential and toxic elements and maternal and fetal parameters were observed. In particular, negative and positive correlations between fetal parameters and magnesium and copper levels in AF, respectively, were seen. The present findings demonstrate the association between minerals in AF and fetal development. © 2015, The Author(s).

Sun, C., Zhao, W., Zhang, Q., et al. (2016) Spatial distribution, sources apportionment and health risk of metals in topsoil in Beijing, China. *International Journal of Environmental Research and Public Health*, 13(7). Available at: <http://www.mdpi.com/1660-4601/13/7/727/pdf>

Abstract:

In order to acquire the pollution feature and regularities of distribution of metals in the topsoil within the sixth ring road in Beijing, a total of 46 soil samples were collected, and the concentrations of twelve elements (Nickel, Ni, Lithium, Li, Vanadium, V, Cobalt, Co, Barium, Ba, Strontium, Sr, Chrome, Cr, Molybdenum, Mo, Copper, Cu, Cadmium, Cd, Zinc, Zn, Lead, Pb) were analyzed. Geostatistics and multivariate statistics were conducted to identify spatial distribution characteristics and sources. In addition, the health risk of the analyzed heavy metals to humans (adult) was evaluated by an U.S. Environmental Protection Agency health risk assessment model. The results indicate that these metals have notable variation in spatial scale. The concentration of Cr was high in the west and low in the east, while that of Mo was high in the north and low in the south. High concentrations of Cu, Cd, Zn, and Pb were found in the central part of the city. The average enrichment degree of Cd is 5.94, reaching the standard of significant enrichment. The accumulation of Cr, Mo, Cu, Cd, Zn, and Pb is influenced by anthropogenic activity, including vehicle exhaustion, coal burning, and industrial processes. Health risk assessment shows that both non-carcinogenic and carcinogenic risks of selected heavy metals are within the safety standard and the rank of the carcinogenic risk of the four heavy metals is Cr > Co > Ni > Cd. © 2016 by the authors; licensee MDPI, Basel, Switzerland.

2. HEALTH EFFECTS

Albarrán-Alonso, J.C., González-Villalva, A., Cano-Gutiérrez, G., *et al.* (2016) Vanadium inhalation and high sucrose beverage ingestion. Study of blood-glucose and changes in lipid metabolism. *Toxicology Letters*, 259: S165. Abstract presented at the XIV International Congress of Toxicology, Merida, Mexico, October 2-6, 2016.

Available at: https://www.researchgate.net/profile/Adriana_Gonzalez-Villalva/publications

Abstract:

Introduction: Vanadium (V) is a metal that is found in large concentrations in some fossil fuels, particularly in the Mexican oil. This metal is adhered to total suspended particles, inhaled and then could reach other organs through systemic circulation. In our model of vanadium inhalation pancreatic and hepatic histology damage was observed, both important organs for the regulation of glucose and lipids in the blood. V may activate the insulin receptor and it has been proposed as an antidiabetic agent. In addition, another public health problem in Mexico is the high sucrose beverage ingestion. The consumption of these drinks exceeds 163 L per person per year; this could be a risk factor for developing chronic metabolic diseases such as obesity and diabetes. So far it has not been studied the effect of inhaled vanadium on glucose regulation neither if the effect of both factors can participate in glucose deregulation.

Objective: Analyze the effect of vanadium inhalation and high sucrose beverage ingestion in blood glycaemia, cholesterol and triglycerides.

Method: Twenty CD-1 mice were randomly separated into four groups: control, vanadium (V), sucrose (S) and sucrose + vanadium (V + S). V and V + S groups inhaled vanadium pentoxide (V₂O₅) 0.01 M for 1 h twice a week for 4 weeks. The S and V + S groups drank water with 30% sucrose daily for 4 weeks. Beverage and food intake

were measured; also waist circumference was measured at day 0 and at 4 weeks of the experiment. Blood samples were collected for glucose and lipid profile including total cholesterol, low-density lipoproteins (LDL), high-density lipoproteins (HDL), and triglycerides.

Results: Decreased food and beverage intake was observed in the three experimental groups. Hypoglycemia and decrease of body weight were observed just in V and V + S groups. In V-group a reduction of abdominal circumference was observed. Serum levels of HDL, total cholesterol and triglycerides increased in S group and decreased in V and V + S groups; in contrast changes in LDL levels were not observed in any group.

Conclusion: Vanadium is described as an insulin enhancer, in this work we observed hypoglycemia in animals exposed to vanadium for a 4-week period of time and an increasing serum levels of HDL and triglycerides, these findings indicate that together, vanadium and high sucrose beverages modify energetic metabolism.

Financial support: CVU 707726, CONACyT. Posgrado en Ciencias Biológicas, UNAM. DGAPA- IN211315, UNAM.

Asemota, E., Scheman, A.J. & Brod, B.A. (2016) Hypersensitivity Reactions to Metallic Implants Containing Vanadium. *Dermatitis: Contact, Atopic, Occupational, Drug*, 27(6): 387-388.

Azeez, I.A., Olopade, F., Laperchia, C., et al. (2016) Regional myelin and axon damage and neuroinflammation in the adult mouse brain after long-term postnatal vanadium exposure. *Journal of Neuropathology and Experimental Neurology*, 75(9): 843-854.

Abstract:

Environmental exposure to vanadium occurs in areas of persistent burning of fossil fuels; this metal is known to induce oxidative stress and oligodendrocyte damage. Here, we determined whether vanadium exposure (3 mg/kg) in mice during the first 3 postnatal months leads to a sustained neuroinflammatory response. Body weight monitoring, and muscle strength and open field tests showed reduction of body weight gain and locomotor impairment in vanadium-exposed mice. Myelin histochemistry and immunohistochemistry for astrocytes, microglia, and nonphosphorylated neurofilaments revealed striking regional heterogeneity. Myelin damage involved the midline corpus callosum and fibers in cortical gray matter, hippocampus, and diencephalon that were associated with axonal damage. Astrocyte and microglial activation was identified in the same regions and in the internal capsule; however, no overt myelin and axon damage was observed in the latter. Double immunofluorescence revealed induction of high tumor necrosis factor (TNF) immunoreactivity in reactive astrocytes. Western blotting analysis showed significant induction of TNF and interleukin-1 β expression. Together these findings show that chronic postnatal vanadium exposure leads to functional deficit and region-dependent myelin damage that does not spare axons. This injury is associated with glial cell activation and proinflammatory cytokine induction, which may reflect both neurotoxic and neuroprotective responses. © 2016 Oxford University Press OR American Association of Neuropathologists.

González-Villalva, A., Colín-Barenque, L., Bizarro-Nevarés, P., et al. (2016) Pollution by metals: Is there a relationship in glycemic control? *Environmental Toxicology and Pharmacology*, 46: 337-343.

Abstract:

There are evidences of environmental pollution and health effects. Metals are pollutants implicated in systemic toxicity. One of the least studied effects, but which is currently becoming more important, is the effect of metals on glycemic control. Metals have been implicated as causes of chronic inflammation and oxidative stress and are associated to obesity, hyperglycemia and even diabetes. Arsenic, iron, mercury, lead, cadmium and nickel have been studied as a risk factor for hyperglycemia and diabetes. There is another group of metals that causes hypoglycemia such as vanadium, chromium, zinc and magnesium by different mechanisms. Zinc, magnesium and chromium deficiency is associated with increased risk of diabetes. This review summarizes some metals involved in glycemic control and pretends to alert health professionals about considering environmental metals as an important factor that could explain the poor glycemic control in patients. Further studies are needed to understand this poorly assessed problem. © 2016 Elsevier B.V.

Keil, D.E., Buck, B., Goossens, D., et al. (2016) Health effects from exposure to atmospheric mineral dust near Las Vegas, NV, USA. *Toxicology Reports*, 3: 785-795.

Abstract:

Desert areas are usually characterized by a continuous deposition of fine airborne particles. Over time, this process results in the accumulation of silt and clay on desert surfaces. We evaluated health effects associated with regional atmospheric dust, or geogenic dust, deposited on surfaces in the Nellis Dunes Recreation Area (NDRA) in Clark County, Nevada, a popular off-road vehicle (ORV) recreational site frequented daily by riders, families, and day campers. Because of atmospheric mixing and the mostly regional origin of the accumulated particles, the re-suspended airborne dust is composed of a complex mixture of minerals and metals including aluminum, vanadium, chromium, manganese, iron, cobalt, copper, zinc, arsenic, strontium, cesium, lead, uranium, and others. Geogenic dust with a median diameter of 4.1 µm was administered via oropharyngeal aspiration to female B6C3F1 mice at doses of 0.01 to 100 mg dust/kg body weight, four times, a week apart, for 28-days. Immuno- and neurotoxicological outcomes 24 h following the last exposure were evaluated. Antigen-specific IgM responses were dose-responsively suppressed at 0.1, 1.0, 10 and 100 mg/kg/day. Splenic and thymic lymphocytic subpopulations and natural killer cell activity also were significantly reduced. Antibodies against MBP, NF-68, and GFAP were not affected, while brain CD3+ T cells were decreased in number. A lowest observed adverse effect level (LOAEL) of 0.1 mg/kg/day and a no observed adverse effect level (NOAEL) of 0.01 mg/kg/day were derived based on the antigen-specific IgM responses. © 2016 The Authors.

Meléndez-García, N., Bizarro, P., Altamirano-Lozano, M., et al. (2016) Female infertility induced by vanadium inhalation in a murine model. *Toxicology Letters*, 259: S235-S236. Abstract presented at the XIV International Congress of

Abstract:

Introduction: Epidemiological studies have proven a relationship between maternal exposure to PM_{2.5} and pregnancy outcomes (low birth weight, intrauterine growth retardation, preterm birth). Particulate matter is composed, among others substances, by metals which produces miscarriages, menstrual disorders and stillbirth in occupationally exposed women. In animal models, particularly vanadium inhalation induces anestrus, lowers progesterone, and estrogen serum concentrations in female mice. However, it has not been evaluated if these alterations produce infertility in exposed females. Metals could interfere with the endocrine system but also in delocalizing expression of connexins and decreasing its expression, which are for important embryo's implantation.

Objective: To evaluate vanadium inhalation effect on connexins in female mice fertility.

Materials and methods: 15 CD1 female mice inhaled vanadium pentoxide (V₂O₅) 0.02 M. The postcoitusV-group inhaled vanadium just 1 h at 5th day after mating, meanwhile V4-WK group inhaled V 1 h, twice a week per four weeks and control group inhaled only the vehicle. Ovaries and uterus were collected and processed for routine histological technique, and also Cx43 and cx26 immunohistochemistry analysis was performed. The number of implantations and corpus luteum per dam were counted.

Results: Control females presented 14 implantation sites, whereas in exposed mice during 4-WKs there were not any implantation sites, therefore we were not able to analyze connexin expression in implantation sites. Because of that we included a poscoitusV-group. Embryo reabsorptions were observed in this former group and decreased stain for both connexins in epithelium and in the decidua.

Conclusions: Vanadium inhalation prevents embryo implantation in females exposed for 4 WKs before, this finding indicates that lower levels of progesterone and estradiol induced by vanadium (reported in previous works) have the potential to induce infertility. In addition, embryo resorption in mice exposed just 1 h at 5th dpc suggests that embryo implantation is very sensitive to vanadium and maybe to other air pollutants. Hence, vanadium should be considered as an endocrine disruptor and reprotoxic.

Financial support:CVU630707. Posgrado en Ciencias Biológicas, UNAM. CONACyT.

Rajendran, N., Seagrave, J., Plunkett, L.M., et al. (2016) A comparative assessment of the acute inhalation toxicity of vanadium compounds. *Inhalation Toxicology*, 28(13): 618-628.

Abstract:

Vanadium compounds have become important in industrial processes, resulting in workplace exposure potential and are present in ambient air as a result of fossil fuel combustion. A series of acute nose-only inhalation toxicity studies was conducted in both rats and mice in order to obtain comparative data on the acute toxicity potential of compounds used commercially. V₂O₃, V₂O₄, and V₂O₅, which have different oxidation states (+3, +4, +5, respectively), were delivered as micronized powders; the highly water-soluble and hygroscopic VOSO₄ (+4) could not be micronized and was

instead delivered as a liquid aerosol from an aqueous solution. V2O5 was the most acutely toxic micronized powder in both species. Despite its lower overall percentage vanadium content, a liquid aerosol of VOSO4 was more toxic than the V2O5 particles in mice, but not in rats. These data suggest that an interaction of characteristics, i.e., bioavailability, solubility and oxidation state, as well as species sensitivity, likely affect the toxicity potential of vanadium compounds. Based on clinical observations and gross necropsy findings, the lung appeared to be the target organ for all compounds. The level of hazard posed will depend on the specific chemical form of the vanadium. Future work to define the inhalation toxicity potential of vanadium compounds of various oxidation states after repeated exposures will be important in understanding how the physico-chemical and biological characteristics of specific vanadium compounds interact to affect toxicity potential and the potential risks posed to human health. © 2016 Informa UK Limited, trading as Taylor & Francis Group.

Shah, S.Z.H., Naveed, A.K. & Rashid, A. (2016) Effects of oral vanadium on glycaemic and lipid profile in rats. *Journal of the Pakistan Medical Association*, 66(12): 1592-1596.

Abstract:

Objective: Vanadyl sulphate, an inorganic tetravalent salt of transition metal vanadium is conventionally used to treat diabetes and by athletes as body-building supplement. Vanadyl sulphate is a constituent of many supplements and herbal preparations available over the counter in many parts of the world. In this study the efficacy of the salt as hypoglycaemic agent and its effects on lipid profile were determined when administered in therapeutic dose range (in humans) to healthy Sprague Dawley rats for a considerable duration. Methods: One hundred and five rats were randomly divided into three groups of 35 rats each. Animals of all three groups were provided normal rodent diet and water ad libitum. Group I animals were administered 0.5 ml plain water through oral gavage while group II and group III rats, 0.25mg/Kg/day and 1.2mg/Kg/day vanadyl sulphate respectively for 24 weeks. At the end of 24 weeks intra-cardiac blood sampling was done and blood glucose, insulin and lipid profile were measured. Results: There was significant decrease in plasma glucose, insulin and HDL-c levels while LDL-c, TGs and TC levels were significantly increased in a dose dependent manner in treated groups. Conclusion: Our study showed that vanadyl sulphate possesses hypoglycaemic effect in healthy rats while insulin levels are also decreased which may be secondary to hypoglycaemia. Moreover it causes unfavorable derangement of lipid parameters in treated rats. In conclusion vanadyl sulphate though contains significant hypoglycaemic effects; its use in humans may be re-evaluated to establish its safety in relation to lipid profile. © 2016, Pakistan Medical Association. All rights reserved.

Suliburska, J., Kocylowski, R., Komorowicz, I., et al. (2016) Concentrations of Mineral in Amniotic Fluid and Their Relations to Selected Maternal and Fetal Parameters. *Biological Trace Element Research*, 172(1): 37-45.

Abstract:

The concentrations of various trace elements in amniotic fluid (AF) change over the

course of pregnancy, with gestational age and fetus growth. The aim of the present study was to evaluate the concentrations of selected essential and toxic elements in AF and their relations to maternal and fetal parameters. The study was carried out in 39 pregnant women, aged 34.6 ± 4.7 years, between weeks 16 and 26 of gestation. Amniotic fluid samples were obtained during the standard procedure of amniocentesis in high-risk patients for chromosomal abnormalities. An inductively coupled plasma mass spectrometry (ICP-MS) technique was used to determine the levels of Al, As, Ba, Cd, Co, Cr, Cu, Mg, Mn, Ni, Sr, U, and V in AF. Body mass and blood pressure were measured in all the women. The basic parameters of fetal development were also assayed. It was found that the age of the mother, the gender of the fetus, and the week of the pregnancy may affect the concentrations of mineral in the amniotic fluid. Moreover, several significant correlations between the essential and toxic elements and maternal and fetal parameters were observed. In particular, negative and positive correlations between fetal parameters and magnesium and copper levels in AF, respectively, were seen. The present findings demonstrate the association between minerals in AF and fetal development. © 2015, The Author(s).

Tarantin, A.V. & Zemlyanova, M.A. (2015) Vanadium essential role and toxic effects. *Human Ecology*, 43(12): 59-64.

Abstract:

At present, the vanadium biological role as an essential microelement is ambiguously perceived by scientists of biomedical research directions. Despite the known expressed toxicity of vanadium various biological effects of this element when administered to the body are of interest. It is shown that vanadium compounds both cause various negative effects playing a role in the pathogenesis of several human diseases, and provide a sufficiently wide range of physiological functions. Vanadium deficiency leads to dysfunction of vital enzyme systems, such as ATPase, protein, ribonuclease and phosphatase, thyroid function regulation, glucose and lipid metabolism, gene of tumor necrosis factor-alpha, protein-activator-1, Interleukin-8, ras, c-raf-1, mitogen-activated protein kinase, p53, nuclear factor kappa B. This indicates vanadium antidiabetic and anticarcinogenic activity. These properties characterize the vanadium as an element of great prospects for the use in dietary supplements and pharmaceutical preparations for the prevention and treatment of socially significant diseases such as diabetes, cancer. This review summarizes the studies of vanadium biological role and its biochemical functions, estimated by its influence on experimental models and human organism. © Northern State Medical University, Arkhangelsk.

3. BIOLOGICAL MECHANISMS

Azeez, I.A., Olopade, F., Laperchia, C., et al. (2016) Regional myelin and axon damage and neuroinflammation in the adult mouse brain after long-term postnatal vanadium exposure. *Journal of Neuropathology and Experimental Neurology*, 75(9): 843-854.

Abstract:

Environmental exposure to vanadium occurs in areas of persistent burning of fossil fuels; this metal is known to induce oxidative stress and oligodendrocyte damage. Here, we determined whether vanadium exposure (3 mg/kg) in mice during the first 3 postnatal months leads to a sustained neuroinflammatory response. Body weight monitoring, and muscle strength and open field tests showed reduction of body weight gain and locomotor impairment in vanadium-exposed mice. Myelin histochemistry and immunohistochemistry for astrocytes, microglia, and nonphosphorylated neurofilaments revealed striking regional heterogeneity. Myelin damage involved the midline corpus callosum and fibers in cortical gray matter, hippocampus, and diencephalon that were associated with axonal damage. Astrocyte and microglial activation was identified in the same regions and in the internal capsule; however, no overt myelin and axon damage was observed in the latter. Double immunofluorescence revealed induction of high tumor necrosis factor (TNF) immunoreactivity in reactive astrocytes. Western blotting analysis showed significant induction of TNF and interleukin-1 β expression. Together these findings show that chronic postnatal vanadium exposure leads to functional deficit and region-dependent myelin damage that does not spare axons. This injury is associated with glial cell activation and proinflammatory cytokine induction, which may reflect both neurotoxic and neuroprotective responses. © 2016 Oxford University Press OR American Association of Neuropathologists.

Cervantes-Yépez, S., Rendon-Huerta, E., Salceda-Sacanelles, R., et al. (2016) Retinal connexin 43 (Cx43) alteration induced by the inhalation of vanadium in a mouse model. *Toxicology Letters*, 259: S161. Abstract presented at the XIV International Congress of Toxicology, Merida, Mexico, October 2-6, 2016.

Abstract:

Introduction: Vanadium (V) is a transition metal adhered to suspended particles in the air of cities with high atmospheric pollution. The eye is directly exposed to the atmosphere, as well as to the elements that enter into the lung and further are distributed through the systemic circulation. It has been reported through ultrastructural techniques that V inhalation disrupts intercellular junctions in mice ependymal epithelium, testicle and blood-brain barrier; through immunohistochemistry it has been reported a decreased Cx43 expression in mice myocardial muscle and testicle as a consequence of increased oxidative stress; and finally, using conventional histological technique, retinal edema has been observed. GAP junctions play a pivotal role in retinal physiology; one of the most abundant connexin in the retina is Cx43. Altogether, the findings mentioned above might suggest retinal GAP junctions disruption as a consequence of V inhalation. **Objective:** To study the effect of V exposure on retinal Cx43 expression. **Material and methods:** Male CD-1 mice were exposed to V₂O₅ [0.02 M] inhalation 1 h at 24 h and twice a week for 1, 4 and 8-week time period and changes in Cx43 expression were identified. Densitometry of the retina Cx43 immunofluorescence photomicrographs was performed and statistical differences were evaluated (ANOVA, *post hoc* Dunnet test, $p < 0.05$).

Results: Cx43 expression decreased at 24 h, one and four weeks after the exposure compared to the control ($p < 0.05$). At eight-week exposure time, Cx43 expression reached values similar to controls. Mechanisms through which Cx43 expression recovered to control's levels will be subjected of future studies.

Conclusions: V inhalation diminishes retinal Cx43 expression possibly due to oxidative stress increment, changes that may have functional repercussions that would need further evaluation.

Financial support: Cervantes-Yépez is a recipient of a fellowship from CONACyT-México (CVU: 609435).

Hamidi, A., Hassani, L., Mohammadi, F., et al. (2016) The biological effects of vanadyl curcumin and vanadyl diacetylcurcumin complexes: the effect on structure, function and oxidative stability of the peroxidase enzyme, antibacterial activity and cytotoxic effect. *Journal of Enzyme Inhibition and Medicinal Chemistry*, 31(6): 1124-1131.

Abstract:

Curcumin has multiple pharmacological effects, but it has poor stability. Complexation of curcumin with metals improves its stability. Here, the effects of vanadyl curcumin and vanadyl diacetylcurcumin on the function and structure of horseradish peroxidase enzyme were evaluated by spectroscopic techniques. Cytotoxic effect of the complexes was also assessed on MCF-7 breast cancer, bladder and LNCaP prostate carcinoma cell line. The results showed that the complexes improve catalytic activity of HRP, and also increase its tolerance against the oxidative condition. The result also indicated that the affinity of HRP for hydrogen peroxide substrate decreases, while the affinity increases for phenol substrate. Circular dichroism and fluorescence spectroscopies showed that compactness of the enzyme structure around the catalytic heme group and the distance between the heme group and tryptophan residue decreases after the binding. The antibacterial and cytotoxic results indicated that the complexes have anticancer potential, but they have no considerable antibacterial activity. © 2015 Informa UK Limited, trading as Taylor & Francis Group.

López-Valdez, N., Espinosa-Aguirre, J., Cerbón-Cervantes, M.A., et al. (2016) CYP1A1 and 1A2 activity evaluation in a murine model of vanadium inhalation. *Toxicology Letters*, 259: S164-S165. Abstract presented at the XIV International Congress of Toxicology, Merida, Mexico, October 2–6, 2016.

Abstract:

Introduction: The respiratory system is particularly vulnerable because of its direct contact with airborne pollutants, termed xenobiotics. One of these pollutants is vanadium pentoxide (V_2O_5) that is found in Mexico City atmosphere, and produces adverse respiratory effects. The chronic exposure to toxicants determines the development of different alterations and pathologies in the system, but also leads to a biological adaptation process called tolerance to protect the respiratory tract against acute effects of frequently-repeated exposures. Several evidences support that some toxicants modulate CYP450's specific activity in lungs and liver, contributing to the development of tolerance, which can influence the detoxification process of further toxicants, specially CYP1A family (CYP1A1, CYP1A2). Both CYP's have been extensively

studied because of their roles in the metabolism of two important classes of environmental carcinogens, polycyclic aromatic hydrocarbons, and arylamines.

Objective: To determine in CD-1 mice the effect of vanadium inhalation in a tolerance model, on the specific activity of CYP1A1 and CYP1A2, in liver and lungs.

Materials and methods: CD-1 male mice weighing 33 ± 2 g were housed in hanging plastic cages under controlled light conditions. Twenty-five mice were randomly placed in an acrylic box, inhaling 0.01 M V_2O_5 for 1 h twice a week for four weeks, and 0.02 M V_2O_5 for 1 h twice a week for four more weeks. Controls (10 mice) inhaled only the vehicle—saline for the same period of time. Five exposed mice, and two controls were sacrificed successively at 2, 4, 5, 6 and 8 weeks. Animals were euthanized by cervical dislocation; lungs and liver from each mouse were immediately and aseptically removed and microsomal fractions were obtained to analyze CYP1A1 and CYP1A2 proteins' activity. Microsomal activities were spectrofluorometrically measured by monitoring the formation of re-sorufin.

Results: No effects on the activity of both cytochromes were observed after vanadium inhalation neither in the liver or the lung.

Conclusions: It was expected that the exposure route influenced the CYP's induction by the agent; however our results showed that V inhalation was insufficient to induce CYP1A1 and CYP1A2, despite the time of exposure and the compound concentration.

Financial support: Posgrado en Ciencias Biológicas, UNAM. The author currently has a CONACYT scholarship (CVU 346684).

Rajendran, N., Seagrave, J., Plunkett, L.M., et al. (2016) A comparative assessment of the acute inhalation toxicity of vanadium compounds. *Inhalation Toxicology*, 28(13): 618-628.

Abstract:

Vanadium compounds have become important in industrial processes, resulting in workplace exposure potential and are present in ambient air as a result of fossil fuel combustion. A series of acute nose-only inhalation toxicity studies was conducted in both rats and mice in order to obtain comparative data on the acute toxicity potential of compounds used commercially. V_2O_3 , V_2O_4 , and V_2O_5 , which have different oxidation states (+3, +4, +5, respectively), were delivered as micronized powders; the highly water-soluble and hygroscopic $VOSO_4$ (+4) could not be micronized and was instead delivered as a liquid aerosol from an aqueous solution. V_2O_5 was the most acutely toxic micronized powder in both species. Despite its lower overall percentage vanadium content, a liquid aerosol of $VOSO_4$ was more toxic than the V_2O_5 particles in mice, but not in rats. These data suggest that an interaction of characteristics, i.e., bioavailability, solubility and oxidation state, as well as species sensitivity, likely affect the toxicity potential of vanadium compounds. Based on clinical observations and gross necropsy findings, the lung appeared to be the target organ for all compounds. The level of hazard posed will depend on the specific chemical form of the vanadium. Future work to define the inhalation toxicity potential of vanadium compounds of various oxidation states after repeated exposures will be important in understanding how the physico-chemical and biological characteristics of specific vanadium compounds interact to affect toxicity potential and the potential risks posed to human health. © 2016 Informa UK Limited, trading as Taylor & Francis Group.

Ścibior, A., Llopis, J., Holder, A.A., *et al.* (2016) Vanadium Toxicological Potential versus Its Pharmacological Activity: New Developments and Research. *Oxidative Medicine and Cellular Longevity*, 2016: 7612347. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5019884/pdf/OMCL2016-7612347.pdf>

Shah, S.Z.H., Naveed, A.K. & Rashid, A. (2016) Effects of oral vanadium on glycaemic and lipid profile in rats. *Journal of the Pakistan Medical Association*, 66(12): 1592-1596.

Abstract:

Objective: Vanadyl sulphate, an inorganic tetravalent salt of transition metal vanadium is conventionally used to treat diabetes and by athletes as body-building supplement. Vanadyl sulphate is a constituent of many supplements and herbal preparations available over the counter in many parts of the world. In this study the efficacy of the salt as hypoglycaemic agent and its effects on lipid profile were determined when administered in therapeutic dose range (in humans) to healthy Sprague Dawley rats for a considerable duration. Methods: One hundred and five rats were randomly divided into three groups of 35 rats each. Animals of all three groups were provided normal rodent diet and water *ad libitum*. Group I animals were administered 0.5 ml plain water through oral gavage while group II and group III rats, 0.25mg/Kg/day and 1.2mg/Kg/day vanadyl sulphate respectively for 24 weeks. At the end of 24 weeks intra-cardiac blood sampling was done and blood glucose, insulin and lipid profile were measured. Results: There was significant decrease in plasma glucose, insulin and HDL-c levels while LDL-c, TGs and TC levels were significantly increased in a dose dependent manner in treated groups. Conclusion: Our study showed that vanadyl sulphate possesses hypoglycaemic effect in healthy rats while insulin levels are also decreased which may be secondary to hypoglycaemia. Moreover it causes unfavorable derangement of lipid parameters in treated rats. In conclusion vanadyl sulphate though contains significant hypoglycaemic effects; its use in humans may be re-evaluated to establish its safety in relation to lipid profile. © 2016, Pakistan Medical Association. All rights reserved.

4. USES OF VANADIUM

Basu, A., Singha Roy, S., Bhattacharjee, A., *et al.* (2016) Vanadium(III)-L-cysteine protects cisplatin-induced nephropathy through activation of Nrf2/HO-1 pathway. *Free Radical Research*, 50(1): 39-55.

Abstract:

Cisplatin (CDDP) is one of the first-line anticancer drugs; however, the major limitation of CDDP therapy is development of nephrotoxicity (25-35% cases), whose precise mechanism mainly involves oxidative stress, inflammation and cell death. Therefore, in search of a potential chemoprotectant, an organovanadium complex, viz.,

vanadium(III)-L-cysteine (VC-III) was evaluated against CDDP-induced nephropathy in mice. CDDP was administered intraperitoneally (5 mg/kg b.w.) and VC-III was given by oral gavage (1 mg/kg b.w.) in concomitant and pre-treatment schedule. The results showed that VC-III administration reduced ($p < 0.001$) serum creatinine and blood urea nitrogen levels, suggesting amelioration of renal dysfunction. VC-III treatment also significantly ($p < 0.001$) prevented CDDP-induced generation of reactive oxygen species, reactive nitrogen species, and onset of lipid peroxidation in kidney tissues of the experimental mice. In addition, VC-III also substantially ($p < 0.001$) restored CDDP-induced depleted activities of the renal antioxidant enzymes such as, superoxide dismutase, catalase, glutathione peroxidase, glutathione-S-transferase, and glutathione (reduced) level. Furthermore, histopathological study also confirmed the renoprotective efficacy of VC-III. Western blotting analysis appended by immunohistochemical data showed that VC-III treatment quite effectively reduced the expression of proinflammatory mediators such as, NFkappabeta, COX-2 and IL-6. VC-III administration also stimulated Nrf2-mediated antioxidant defense system by promotion of downstream antioxidant enzymes, such as HO-1. Moreover, treatment with VC-III significantly ($p < 0.001$) enhanced CDDP-mediated cytotoxicity in MCF-7 and NCI-H520 human cancer cell lines. Thus, VC-III can serve as a suitable chemoprotectant and increase the therapeutic window of CDDP in cancer patients.

Elnaggar, M.E., Wahba, M., El Shebiney, S.A., et al. (2016) Functionalization of nanostructured vanadium zirconium metal complex: Shifting the risk-benefit ratio. *Toxicology Letters*, 258: S262. Abstract presented at the the 52nd Congress of the European Societies of Toxicology (EUROTOX) Fibes Congress Center Seville, Spain, 04th-07th September 2016.

Abstract:

Vanadium is an important micronutrient with multiple beneficial biological activities. However, it has limited medicinal applications for its high toxicity. Structuring materials at nanoscale provide more effectiveness, low systemic toxicity, targeted delivery and controlled release of the material. The present study was conducted to investigate the effect of the novel nanostructured vanadium zirconium against lipopolysaccharide (LPS) induced acute liver damage. Lps was used in a dose of 10 $\mu\text{g}/\text{kg}$, intraperitoneally. The hepatic tissue was insulted and showed high FAB and MLC reactivity. Blood aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels were elevated. Apoptotic and necrotic changes in hepatocytes were observed. Treatment with VnZrO showed protective effect and minimal toxic effect was demonstrated in DNA fragmentation test. Moreover, oxidative markers were leveled down and the antioxidant GSH pool was restored. This study elucidated the possible advantage of nanostructured metal based materials for inflammatory conditions. However, further toxicological investigation is needed to weigh its real beneficial actions.

Farias, C.L.A., Cadena, S., Martinez, G.R., et al. (2016) SUN-P076: Complex Xyloglucan Vanadium Decreases the Cell Proliferation and Alters the Oxidative Metabolism of Cells B16F 10 in Vitro. *Clinical Nutrition*, 35, Supplement 1: S72.

Abstract presented at the the 38th ESPEN Congress, Copenhagen, Denmark, 17–20 September 2016.

Abstract:

Rationale: Polysaccharides have been demonstrated to have important biological effects, including antitumor action. In addition to exercise their effects in native form, chemically modified polysaccharides have been studied in order to potentiate their effects. Among them are the complex carbohydrates and metal, which prove to be potential therapeutic agents. Among the polysaccharides of interest are the xyloglucans, which are used in the pharmaceutical and food industry, acting as thickeners, stabilizers, gelling and source of fiber. Vanadium is a trace element widely distributed in nature. The objective of this study was to evaluate the effects of xyloglucans (extracted from *Copaifera Langsdorffii*) and your complex with oxovanadium (XGC/VO) on murine melanoma cells, B16F10. Methods: The antitumoral effect was evaluated by cell viability, proliferation, morphology, and cell death and metabolism. Results: After treatment with 2.5–300 $\mu\text{g} \cdot \text{mL}^{-1}$ for 24, 48 and 72 hours, cell viability and proliferation was significantly reduced, about 50%. On the other hand, treatment did not affect the cell cycle. A decrease of cells adhered to the coverslip was observed by optical microscopy, indicating that the polysaccharide may be interfering with cell adhesion. Analysis of cell death by annexin V-FITC/PI revealed that with 200 $\mu\text{g} \cdot \text{mL}^{-1}$ was induced death. The treatment was able to inhibit about 50% oxygen consumption of cells, after treatment with 5 and 25 $\mu\text{g} \cdot \text{mL}^{-1}$. The analysis of RT-qPCT shows a tendency to decrease the expression of the enzyme pyruvate kinase to 25 and 200 $\mu\text{g} \cdot \text{mL}^{-1}$ and a significant decrease in the F1 subunit of ATP synthase with 200 $\mu\text{g} \cdot \text{mL}^{-1}$. Conclusion: These results demonstrate that the complex is important antitumor effect and suggests that this effect is due to interference in the metabolism, affecting mainly the mitochondrial functions.

Hamidi, A., Hassani, L., Mohammadi, F., *et al.* (2016) The biological effects of vanadyl curcumin and vanadyl diacetylcurcumin complexes: the effect on structure, function and oxidative stability of the peroxidase enzyme, antibacterial activity and cytotoxic effect. *Journal of Enzyme Inhibition and Medicinal Chemistry*, 31(6): 1124-1131.

Abstract:

Curcumin has multiple pharmacological effects, but it has poor stability. Complexation of curcumin with metals improves its stability. Here, the effects of vanadyl curcumin and vanadyl diacetylcurcumin on the function and structure of horseradish peroxidase enzyme were evaluated by spectroscopic techniques. Cytotoxic effect of the complexes was also assessed on MCF-7 breast cancer, bladder and LNCaP prostate carcinoma cell line. The results showed that the complexes improve catalytic activity of HRP, and also increase its tolerance against the oxidative condition. The result also indicated that the affinity of HRP for hydrogen peroxide substrate decreases, while the affinity increases for phenol substrate. Circular dichroism and fluorescence spectroscopies showed that compactness of the enzyme structure around the catalytic heme group and the distance between the heme group and tryptophan residue decreases after the binding. The antibacterial and cytotoxic results indicated

that the complexes have anticancer potential, but they have no considerable antibacterial activity. © 2015 Informa UK Limited, trading as Taylor & Francis Group.

Jiang, P., Dong, Z., Ma, B., et al. (2016) Effect of Vanadyl Rosiglitazone, a New Insulin-Mimetic Vanadium Complexes, on Glucose Homeostasis of Diabetic Mice. *Applied Biochemistry and Biotechnology*, 180(5): 841-851.

Abstract:

Diabetes has been cited as the most challenging health problem in the twenty-first century. Accordingly, it is urgent to develop a new type of efficient and low-toxic antidiabetic medication. Since vanadium compounds have insulin-mimetic and potential hypoglycemic activities for type 1 and type 2 diabetes, a new trend has been developed using vanadium and organic ligands to form a new compound in order to increase the intestinal absorption and reduce the toxicity of vanadium compound. In the current investigation, a new organic vanadium compounds, vanadyl rosiglitazone, was synthesized and determined by infrared spectra. Vanadyl rosiglitazone and three other organic vanadium compounds were administered to the diabetic mice through oral administration for 5 weeks. The results of mouse model test indicated that vanadyl rosiglitazone could regulate the blood glucose level and relieve the symptoms of polydipsia, polyphagia, polyuria, and weight loss without side effects and was more effective than the other three organic vanadium compounds including vanadyl trehalose, vanadyl metformin, and vanadyl quercetin. The study indicated that vanadyl rosiglitazone presents insulin-mimetic activities, and it will be a good potential candidate for the development of a new type of oral drug for type 2 diabetes.

Lei, J., Wang, J., Huo, Y., et al. (2016) 4-Fluoro-N'-(2-hydroxy-3-methoxybenzylidene) benzohydrazide and its oxidovanadium (V) complex: Syntheses, crystal structures and insulin-enhancing activity. *Acta Chimica Slovenica*, 63(3): 670-677. Available at: <https://journals.matheo.si/index.php/ACSi/article/viewFile/2589/1040>

Abstract:

A hydrated hydrazone compound, 4-fluoro-N'-(2-hydroxy-3-methoxybenzylidene)benzohydrazide monohydrate (H2L · H2O), was prepared and characterized by elemental analysis, HRMS, IR, UV-Vis and ¹H NMR spectroscopy. Reaction of H2L, kojic acid (5-hydroxy-2-(hydroxymethyl)-4H-pyran-4-one; Hka) and VO(acac)₂ in methanol afforded a novel oxidovanadium(V) complex, [VO(ka)L]. The complex was characterized by elemental analysis, IR, UV-Vis and ¹H NMR spectroscopy. Thermal analysis was also performed. Structures of H2L and the complex were further confirmed by single crystal structural X-ray diffraction. The vanadium complex is the first structurally characterized vanadium complex of kojic acid. Insulin-mimetic tests on C2C12 muscle cells indicate that the complex significantly stimulated cell glucose utilization with cytotoxicity at 0.11 g L⁻¹.

León, I.E., Cadavid-Vargas, J.F., Resasco, A., et al. (2016) In vitro and in vivo antitumor effects of the VO-chrysin complex on a new three-dimensional osteosarcoma spheroids model and a xenograft tumor in mice. *Journal of Biological Inorganic Chemistry*, 21(8): 1009-1020.

Abstract:

Osteosarcoma (OS) is the most common primary tumor of bone, occurring predominantly in the second decade of life. High-dose cytotoxic chemotherapy and surgical resection have improved prognosis, with long-term survival for patients with localized disease. Vanadium is an ultra-trace element that after being absorbed accumulates in bone. Besides, vanadium compounds have been studied during recent years to be considered as representative of a new class of non-platinum antitumor agents. Moreover, flavonoids are a wide family of polyphenolic compounds that display many interesting biological effects. Since coordination of ligands to metals can improve the pharmacological properties, we report herein, for the first time, the in vitro and in vivo effects of an oxidovanadium(IV) complex with the flavonoid chrysin on the new 3D human osteosarcoma and xenograft osteosarcoma mice models. The pharmacological results show that VOchrysin inhibited the cell viability affecting the shape and volume of the spheroids and VOchrysin suppressed MG-63 tumor growth in the nude mice without inducing toxicity and side effects. As a whole, the results presented herein demonstrate that the antitumor action of the complex was very promissory on human osteosarcoma models, whereby suggesting that VOchrysin is a potentially good candidate for future use in alternative antitumor treatments. Graphical Abstract: [Figure not available: see fulltext.] © 2016 SBIC.

Li, X., Bai, L., Dong, Y., et al. (2016) Vanadyl complexes work with cinnamaldehyde in promoting cell viability under the β amyloid burden in SHSY5Y neural cells. *Journal of Chinese Pharmaceutical Sciences*,25(10): 754-763.

Abstract:

The Alzheimer's disease (AD) is one of the common cognitive disorders in the elderly. AD shares some similar pathological characters with diabetes mellitus (DM), suggesting potential application of anti-diabetic agents, such as vanadyl complexes, in therapeutic treatment of AD. In the present work, we studied the effects of vanadyl acetylacetonate (VO(acac)₂) and cinnamaldehyde (CA) on an AD model based on SH-SY5Y neural cells. The experimental results showed that VO(acac)₂ at sub-micromolar concentrations could improve the viability of neural cells with or without increased β -amyloid (A β) burden; and the combination of VO(acac)₂ and CA showed an additive cell protection effects. Further investigation revealed that for SH-SY5Y neural cells, VO(acac)₂ could activate PPAR γ -AMPK signal transduction and inhibit GSK 3 β , one of the major kinases for Tau hyperphosphorylation. Meanwhile, CA could correct the abnormal mitochondrial morphology due to A β -induced excessive mitochondrial fission, thus restoring/enhancing the mitochondrial function. In addition, both VO(acac)₂ and CA decreased intracellular reactive oxygen species (ROS) level and inhibited formation of toxic A β oligomers. Overall, VO(acac)₂ might work with CA in improving the neural cell viability under the A β burden, suggesting application of vanadium metallodrugs in AD treatment. © 2016 Journal of Chinese Pharmaceutical Sciences, School of Pharmaceutical Sciences, Peking University.

5. ENVIRONMENTAL EFFECTS in PLANTS and SOIL

Gasparotto Sattler, J.A., Machado De-Melo, A.A., do Nascimento, K.S., et al. (2016) Essential minerals and inorganic contaminants (barium, cadmium, lithium, lead and vanadium) in dried bee pollen produced in Rio Grande do Sul State, Brazil. *Food Science and Technology*, 36(3): 505-509.

Abstract:

Like other beehive products, such as honey, royal jelly and propolis, bee pollen has attracted great interest because of the health benefits it can provide when consumed. Bee pollen has high contents of sugars and proteins and a low content of lipids, it is also a rich source of vitamins and other bioactive compounds, which makes it an attractive micronutrient supplement. However, few studies have investigated its composition. Therefore, the aim of this study was to characterize the essential minerals and inorganic contaminants present in bee pollen produced at apiaries in Rio Grande do Sul State, Brazil. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) revealed the presence of 8 essential minerals (calcium, iron, copper, chromium, manganese, molybdenum, phosphorus and zinc) in the 5 analyzed samples; 6 of them were in sufficiently high amounts to meet dietary requirements. Of the 5 inorganic contaminants assessed (barium, cadmium, lithium, lead and vanadium), only cadmium was present at levels over the International Honey Commission's standards. All bee pollen samples showed a high content of the 8 essential minerals. Contamination usually results from the use of pesticides, fertilizers and other chemicals in agriculture; thus, monitoring of its levels must be included in bee pollen analysis.

Imtiaz, M., Mushtaq, M.A., Rizwan, M.S., et al. (2016) Comparison of antioxidant enzyme activities and DNA damage in chickpea (*Cicer arietinum* L.) genotypes exposed to vanadium. *Environmental Science and Pollution Research*, 23(19): 19787-19796.

Available

at: https://www.researchgate.net/publication/305314165_Comparison_of_antioxidant_enzyme_activities_and_DNA_damage_in_chickpea_Cicer_arietinum_L_genotypes_exposed_to_vanadium

Abstract:

The present study was done to elucidate the effects of vanadium (V) on photosynthetic pigments, membrane damage, antioxidant enzymes, protein, and deoxyribonucleic acid (DNA) integrity in the following chickpea genotypes: C-44 (tolerant) and Balkasar (sensitive). Changes in these parameters were strikingly dependent on levels of V, at 60 and 120 mg V L⁻¹ induced DNA damage in Balkasar only, while photosynthetic pigments and protein were decreased from 15 to 120 mg V L⁻¹ and membrane was also damaged. It was shown that photosynthetic pigments and protein production declined from 15 to 120 mg V L⁻¹ and the membrane was also damaged, while DNA damage was not observed at any level of V stress in C-44. Moreover, the antioxidant enzyme activities such as superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD) were increased in both genotypes of chickpea against V stress; however, more activities were observed in C-44 than Balkasar. The

results suggest that DNA damage in sensitive genotypes can be triggered due to exposure of higher vanadium.

Li, D., Jiang, J., Li, T., et al. (2016) Soil heavy metal contamination related to roasted stone coal slag: a study based on geostatistical and multivariate analyses. *Environmental Science and Pollution Research*,23(14): 14405-14413.

Abstract:

Soil was examined for vanadium (V) and related metal contamination near a stone coal mine in Hubei Province, China. In total, 92 surface and vertical (0–200 cm) soil samples were collected from the site. A handheld X-ray fluorescence spectrometer was used for in situ analysis of the soil concentrations of heavy metals, including V, chromium (Cr), copper (Cu), manganese (Mn), zinc (Zn), and lead (Pb). The mean concentrations of these metals were 931, 721, 279, 223, 163, and 11 mg/kg, respectively. Based on the Chinese Environmental Quality Standard for Soils guidelines, up to 88.0, 76.1, and 56.5 % of the soil samples had single factor pollution indices >3 for V, Cr, and Cu, respectively. Furthermore, 2.2 % of samples were slightly polluted with Zn, while there was no Mn or Pb contamination. GaussAmp curve fitting was performed based on the sample frequency distribution of the Nemerow pollution index. The fitted mean was 5.99, indicating severe pollution. The heavy metals were clustered into two groups, V/Cr/Cu/Zn and Mn/Pb, based on the spatial distributions, the Pearson correlation and principal component analyses. The positive correlations within the V/Cr/Cu/Zn group suggested that they originated from roasted stone coal slag. Finally, the negative correlation between the two groups was attributed to mechanical mixing of the slag and original soil. © 2016, Springer-Verlag Berlin Heidelberg.

Sun, C., Zhao, W., Zhang, Q., et al. (2016) Spatial distribution, sources apportionment and health risk of metals in topsoil in Beijing, China. *International Journal of Environmental Research and Public Health*,13(7). Available at: <http://www.mdpi.com/1660-4601/13/7/727/pdf>

Abstract:

In order to acquire the pollution feature and regularities of distribution of metals in the topsoil within the sixth ring road in Beijing, a total of 46 soil samples were collected, and the concentrations of twelve elements (Nickel, Ni, Lithium, Li, Vanadium, V, Cobalt, Co, Barium, Ba, Strontium, Sr, Chrome, Cr, Molybdenum, Mo, Copper, Cu, Cadmium, Cd, Zinc, Zn, Lead, Pb) were analyzed. Geostatistics and multivariate statistics were conducted to identify spatial distribution characteristics and sources. In addition, the health risk of the analyzed heavy metals to humans (adult) was evaluated by an U.S. Environmental Protection Agency health risk assessment model. The results indicate that these metals have notable variation in spatial scale. The concentration of Cr was high in the west and low in the east, while that of Mo was high in the north and low in the south. High concentrations of Cu, Cd, Zn, and Pb were found in the central part of the city. The average enrichment degree of Cd is 5.94, reaching the standard of significant enrichment. The accumulation of Cr, Mo, Cu, Cd, Zn, and Pb is influenced by anthropogenic activity, including vehicle

exhaustion, coal burning, and industrial processes. Health risk assessment shows that both non-carcinogenic and carcinogenic risks of selected heavy metals are within the safety standard and the rank of the carcinogenic risk of the four heavy metals is Cr > Co > Ni > Cd. © 2016 by the authors; licensee MDPI, Basel, Switzerland.

Wallner-Kersanach, M., Mirlean, N., Da Graça Zepka Baumgarten, M., et al. (2016) Temporal evolution of the contamination in the southern area of the Patos Lagoon estuary, RS, Brazil. *Journal of Integrated Coastal Zone Management*, 16(3): 263-279.
Keywords: Contamination; Environmental management; Estuary; Nutrients; Trace metals

Abstract:

The southern area of the Patos Lagoon estuary has been subjected to intense industrial and port-related activities which have not only caused meaningful changes in the landscape but also degraded aquatic resources by contaminating them with dissolved nutrients and trace metals in the last decades. This study aims at compiling data on the development that has happened in the urban and industrial occupation in Rio Grande, a city located in the south of Rio Grande do Sul, RS, Brazil, by relating it to the main results of contamination indicators in the estuarine environment regarding water, sediment, soil and atmosphere. Bibliographic data have shown an increase in domestic effluents around the city in the 1980's, mainly in more sheltered areas, such as the Saco da Mangueira, where cyanobacteria eutrophication has often occurred because of the high concentration of nutrients. The content of trace metals in the water of channel areas of the estuary was always lower than the maximum limit established by Brazilian quality criteria. However, the sediment showed higher concentrations of some trace metals (e.g. copper, lead, nickel, vanadium and zinc), the metalloid As and Hg than the maximum concentrations established by the legislation, mainly in several places around urban, industrial and port areas. The labile fraction (or potentially bioavailable) in the water and in the sediment showed that trace metals have provided significant contributions to sheltered areas, such as marinas, but have exceeded in shipyards. Trace metals in the urban soil and man-made ground of the city indicated that there were anthropogenic contributions, mainly by mercury. Anomalies in the content of lead found in the atmospheric particulate matter and acid rain were also reported. Therefore, more severe environmental policies, effective control, industrial wastewater treatment and control of atmospheric emissions must be carried out in order to maintain environmental quality and public health. The city authorities in Rio Grande need to implement the existing integrated estuary management program in a proper and practical way, involving stakeholders and local governments.

6. ENVIRONMENTAL EFFECTS in TERRESTRIAL ORGANISMS

Kastratovic, V., Jacimovic, Ž., Bigovic, M., et al. (2016) Environmental status and geochemical assessment sediments of Lake Skadar, Montenegro. *Environmental Monitoring and Assessment*, 188(8): 449.

Abstract:

The environmental mobility and geochemical partitioning of ten metals were examined in sediments collected from the six locations around Lake Skadar in Montenegro. A three-step sequential extraction procedure was used to determine the distribution of the metals in various substrates of lacustrine sediments, and the concentrations were measured in the liquid extract by ICP-OES. The largest portion of the total amount of cadmium, strontium and manganese can be found in sediment bound to the hydrated iron and manganese oxides; cobalt, lead, copper and nickel in the oxidizable fraction and the highest portion of chromium, vanadium and zinc are in the residual fraction. The most mobilized and potentially mobile metals are strontium, cadmium and cobalt while the most immobilized metals are chromium, vanadium and zinc. Based on geochemical parameters, an assessment of sediment contamination by the investigated metals was performed and the results showed potential risks ranging from “no risk” to “low risk” to the environment. © 2016, Springer International Publishing Switzerland.

Yuan, Z.H., Wang, J.P., Zhang, K.Y., et al. (2016) Effect of Vanadium and Tea Polyphenols on Intestinal Morphology, Microflora and Short-Chain Fatty Acid Profile of Laying Hens. *Biological Trace Element Research*, 174(2): 419-427.

Abstract:

Vanadium (V) is a trace element which can induce dysfunction of gastro-intestine and egg quality deterioration of laying hens. This study was conducted to determine the effect of tea polyphenols (TP) on intestinal morphology, microflora, and short-chain fatty acid (SCFA) profile of laying hens fed vanadium containing diets. A total of 120 Lohman laying hens (67-week-old) were randomly divided into 4 groups with 6 replicates and 5 birds each for a 35-day feeding trial. The dietary treatments were as follows: (1) control (CON), fed a basal diet; (2) vanadium treatment (V10), CON +10 mg V/kg; (3) TP treatment 1 (TP1): V10 + 600 mg TP/kg; (4) TP treatment 2 (TP2): V10 + 1000 mg TP/kg. Fed 10 mg V/kg diets to laying hens did not affect the cecum flora diversity index (H), degree of homogeneity (EH), and richness (S), but hens fed TP2 diet decreased the H, EH, and S ($P < 0.05$). The cecum butyrate acid concentration was lower in V10 treatment and higher in TP2 treatment ($P < 0.05$). Addition of 10 mg/kg V resulted in an increased ($P < 0.01$) duodenal cell apoptosis rate, and 1000 mg/kg TP supplementation overcame ($P < 0.01$) this reduction effect induced by vanadium. The results indicated that supplementation of 10 mg/kg vanadium increased duodenal cell apoptosis and reduced cecum butyrate acid content. Addition of 1000 mg/kg TP increased the SCFA production to affect cecum flora ecology and protected the duodenal cell from excess apoptosis caused by vanadium.

7. ENVIRONMENTAL EFFECTS in AQUATIC ORGANISMS

Ayari, J., Agnan, Y. & Charef, A. (2016) Spatial assessment and source identification of trace metal pollution in stream sediments of Oued El Maadene basin, northern Tunisia. *Environmental Monitoring and Assessment*, 188(7). Available at: <http://biogeochimie.fr/Files/Other/pdf/Ayari et al 2016 EMA.pdf>

Abstract:

An extensive spatial survey was conducted on trace metal content in stream sediments from Oued El Maadene basin, northern Tunisia. Our objectives were to evaluate the level of trace metal pollution and associated ecological risk and identify the major sources of metal pollution. A total of 116 stream sediment samples were collected and analysed for total As, Cd, Cr, Cu, Ni, Pb, V, Zn, and Zr concentrations. The results showed that concentrations of Cr, Ni, V, and Zr were close to natural levels. In contrast, As, Cd, Cu, Pb, and Zn had elevated concentrations and enrichment factors compared to other contaminated regions in northern Tunisia. Ecological risk to aquatic ecosystems was highlighted in most areas. Principal component analysis showed that Cr, Ni, V, and Zr mainly derived from local soil and bedrock weathering, whilst As, Cd, Pb, and Zn originated from mining wastes. Trace metals could be dispersed downstream of tailings, possibly due to surface runoff during the short rainy season. Surprisingly, Cu, and to a lesser extent As, originated from agricultural activities, related to application of Cu-based fungicides in former vineyards and orchards. This study showed that, despite the complete cessation of mining activities several decades ago, metal pollution still impacts the local environment. This large pollution, however, did not mask other additional sources, such as local agricultural applications of fungicides. © 2016, Springer International Publishing Switzerland.

de Almeida, E.V., Kütter, V.T., Marques, E.D., et al. (2016) First assessment of trace metal concentration in mangrove crab eggs and other tissues, SE Brazil. *Environmental Monitoring and Assessment*, 188(7): 421.

Abstract:

The mangrove crab *Ucides cordatus* is widespread in the Brazilian coast, which has an important role in nutrient cycling. This species reproduces in summer and females carry eggs about a month, when they maintain contact with water and sediments. It remains unclear if trace metals can be absorbed or adsorbed by the eggs during development. The present study aims to investigate, for the first time, trace metal concentrations in ovigerous female tissues and eggs of *U. cordatus* in two areas with different metal pollution levels in the Southeastern Brazil. Samples were collected in two different mangroves, Guanabara Bay (GB) highly polluted environment and Paraíba do Sul River (PSR). In both populations, we observed significant increase of V, Cr, and Mn concentrations along eggs maturation. The higher metals averages were found in PSR population. This trend was reported since the 1990s and lower concentrations in GB marine organisms were attributed to reducing conditions, high organic load, and the presence of sulfide ions. These conditions restrict the

bioavailability of metals in the bay, with exception of Mn. No significant differences were observed in gills and muscles. In both populations of the present study, V, Zn, As, and Pb were higher in eggs of initial stage, whereas Mn, Ni, Cu, and Cd were higher in hepatopancreas. Beside this, V, Cr, Mn, As, and Pb showed an increase concerning egg development. Thus, V, As, and Pb in eggs come from two sources previous discussed: females and environment. Zinc came mainly from females due to essential function. Those new information should be considered as one of the mechanisms of trace metal transfer to the trophic chain, between benthonic and pelagic environment. © 2016, Springer International Publishing Switzerland.

Guo, W., Yin, S-H., Xu, J-X., et al. (2016) Pollution characteristics and ecological risk assessment of vanadium in sediments of the Three Gorges Reservoir (Chongqing-Yichang Section). *Huanjing Kexue/Environmental Science*, 37(9): 3333-3339.

Abstract:

In order to investigate the pollution characteristics of vanadium in sediments of the Three Gorges Reservoir (TGR), 67 sediment samples were collected from the section between Chongqing to Yichang in TGR. The concentration and chemical speciation of vanadium were measured and the spatial distribution of vanadium was discussed. Current pollution level of vanadium in TGR sediments was assessed by index of geoaccumulation and Håkanson ecological risk index. The results showed that: (1)the range of vanadium concentrations in TGR was 89.4-175.2 mg·kg⁻¹ and the average concentration was 123.7 mg·kg⁻¹, which was slightly higher than the background value in sediments of Yangtze River. (2)the spatial distribution of vanadium in TGR sediments showed that vanadium concentrations in the mainstream of TGR were higher than those in tributaries and the vanadium contents in the sediments in downstream were higher than those in upstream in term of the mainstream of TGR. (3) highest vanadium concentration was found in the sediment in a developed county, indicating that this high level of vanadium concentration was attributed to anthropogenic input. (4) chemical forms of vanadium in sediments were mainly in residual state (80%-89%, mass fraction), which had a significant positive correlation with total concentrations in sediments. (5) vanadium contamination degree and potential environmental risk in TGR sediments were weak. © 2016, Science Press. All right reserved.

Shi, Y.X., Mangal, V. & Guéguen, C. (2016) Influence of dissolved organic matter on dissolved vanadium speciation in the Churchill River estuary (Manitoba, Canada). *Chemosphere*, 154: 367-374

Abstract:

Diffusive gradients in thin films (DGT) devices were used to investigate the temporal and spatial changes in vanadium (V) speciation in the Churchill estuary system (Manitoba). Thirty-six DGT sets and 95 discrete water samples were collected at 8 river and 3 estuary sites during spring freshet and summer base flow. Dissolved V concentration in the Churchill River at summer base flow was approximately 5 times higher than those during the spring high flow (27.3 ± 18.9 nM vs 4.8 ± 3.5 nM). DGT-labile V showed an opposite trend with greater values found during the spring high

flow (2.6 ± 1.8 nM vs 1.4 ± 0.3 nM). Parallel factor analysis (PARAFAC) conducted on 95 excitation-emission matrix spectra validated four humic-like (C1C4) and one protein-like (C5) fluorescent components. Significant positive relationship was found between protein-like DOM and DGT-labile V ($r = 0.53$, $p < 0.05$), indicating that protein-like DOM possibly affected the DGT-labile V concentration in Churchill River. Sediment leachates were enriched in DGT-labile V and protein-like DOM, which can be readily released when river sediment began to thaw during spring freshet.

Wallner-Kersanach, M., Mirlean, N., Da Graça Zepka Baumgarten, M., et al. (2016) Temporal evolution of the contamination in the southern area of the Patos Lagoon estuary, RS, Brazil. *Journal of Integrated Coastal Zone Management*, 16(3): 263-279.

Abstract:

The southern area of the Patos Lagoon estuary has been subjected to intense industrial and port-related activities which have not only caused meaningful changes in the landscape but also degraded aquatic resources by contaminating them with dissolved nutrients and trace metals in the last decades. This study aims at compiling data on the development that has happened in the urban and industrial occupation in Rio Grande, a city located in the south of Rio Grande do Sul, RS, Brazil, by relating it to the main results of contamination indicators in the estuarine environment regarding water, sediment, soil and atmosphere. Bibliographic data have shown an increase in domestic effluents around the city in the 1980's, mainly in more sheltered areas, such as the Saco da Mangueira, where cyanobacteria eutrophication has often occurred because of the high concentration of nutrients. The content of trace metals in the water of channel areas of the estuary was always lower than the maximum limit established by Brazilian quality criteria. However, the sediment showed higher concentrations of some trace metals (e.g. copper, lead, nickel, vanadium and zinc), the metalloid As and Hg than the maximum concentrations established by the legislation, mainly in several places around urban, industrial and port areas. The labile fraction (or potentially bioavailable) in the water and in the sediment showed that trace metals have provided significant contributions to sheltered areas, such as marinas, but have exceeded in shipyards. Trace metals in the urban soil and man-made ground of the city indicated that there were anthropogenic contributions, mainly by mercury. Anomalies in the content of lead found in the atmospheric particulate matter and acid rain were also reported. Therefore, more severe environmental policies, effective control, industrial wastewater treatment and control of atmospheric emissions must be carried out in order to maintain environmental quality and public health. The city authorities in Rio Grande need to implement the existing integrated estuary management program in a proper and practical way, involving stakeholders and local governments.

8. MISCELLANEOUS

Scior, T., Guevara-Garcia, J.A., Do, Q.-., et al. (2016) Why antidiabetic vanadium complexes are not in the pipeline of "big pharma" drug research? a critical review. *Current Medicinal Chemistry*, 23(25): 2874-2891.

Abstract:

Public academic research sites, private institutions as well as small companies have made substantial contributions to the ongoing development of antidiabetic vanadium compounds. But why is this endeavor not echoed by the globally operating pharmaceutical companies, also known as Big Pharma? Intriguingly, today's clinical practice is in great need to improve or replace insulin treatment against Diabetes Mellitus (DM). Insulin is the mainstay therapeutically and economically. So, why do those companies develop potential antidiabetic drug candidates without vanadium (vanadium-free)? We gathered information about physicochemical and pharmacological properties of known vanadium-containing antidiabetic compounds from the specialized literature, and converted the data into explanations (arguments, the pros and cons) about the underpinnings of antidiabetic vanadium. Some discoveries were embedded in chronological order while seminal reviews of the last decade about the Medicinal chemistry of vanadium and its history were also listed for further understanding. In particular, the concepts of so-called noncomplexed or free vanadium species (i.e. inorganic oxido-coordinated species) and biogenic speciation of antidiabetic vanadium complexes were found critical and subsequently documented in more details to answer the question. © 2016 Bentham Science Publishers.

Xing, S., Tian, K. & Fan, Q. (2016) Development of Vanadium Reference Materials Used in Water Environmental Monitoring. *Huaxue Shiji*, 38(8), 768-770.

Abstract:

This work describes the development of the vanadium reference materials used in water pollution monitoring for the first time. It includes validation of quantity value, homogeneity and stability tests, and statistic of measurement data and so on. It was prepared using the weight method. The homogeneity and stability was investigated by national standard method for determination of vanadium by inductively coupled plasma-mass, and uncertainties were respectively evaluated in development. The results indicated the sample was homogeneous and stable, and lift time of the vanadium reference materials could maintain at least 24 months. The certified value for CRM was 0.234 mg / L with the relative expanded uncertainty form 3.4% (k = 2), the serial number of national standard: GSB 07-3175—2014.