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Vanadium Health Research Programme: Recent Published Literature

January 2018 – March 2018

Report to Vanitec

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Introduction

This report presents the bibliographic details of the 38 papers identified as being published during the period January 2018 to March 2018.

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

Chen, X., Ward, T.J., Cao, J.*, et al.* (2018) Determinants of personal exposure to fine particulate matter (PM2.5) in adult subjects in Hong Kong. *Science of the Total Environment,* 628–629: 1165-1177.

Keywords: Personal exposure; Fine particulate matter; Particulate constituents; Time-activity diaries; Mixed-effects model

Abstract:
Personal monitoring for fine particulate matter (PM2.5) was conducted for adults (48 subjects, 18–63 years of age) in Hong Kong during the summer and winter of 2014–2015. All filters were analyzed for PM2.5 mass and constituents (including carbonaceous aerosols, water-soluble ions, and elements). We found that season (p = 0.02) and occupation (p 37.3%) to personal exposures for PM2.5 mass and most components. For all subjects, a one-unit (2.72 μg/m3) increase in ambient PM2.5 was associated with a 0.75 μg/m3 (95% CI: 0.59–0.94 μg/m3) increase in personal PM2.5 exposure. The adjusted mixed-effects models included information extracted from individual's activity diaries as covariates. The results showed that season, occupation, time indoors at home, in transit, and cleaning were significant determinants for PM2.5 components in personal exposure (R2β = 0.06–0.63, p < 0.05), contributing to 3.0–70.4% of the variability. For one-hour extra time spent at home, in transit, and cleaning an average increase of 1.7–3.6% (ammonium, sulfate, nitrate, sulfur), 2.7–12.3% (elemental carbon, ammonium, titanium, iron), and 8.7–19.4% (ammonium, magnesium ions, vanadium) in components of personal PM2.5 were observed, respectively. In this research, the within-individual variance component dominated the total variability for all investigated exposure data except PM2.5 and EC. Results from this study indicate that performing long-term personal monitoring is needed for examining the associations of mass and constituents of personal PM2.5 with health outcomes in epidemiological studies by describing the impacts of individual-specific data on personal exposures.

Copat, C., Grasso, A., Fiore, M.*, et al.* (2018) Trace elements in seafood from the Mediterranean sea: An exposure risk assessment. *Food and Chemical Toxicology,* 115: 13-19.

Keywords: THQ; Risk; Seafood; Metals; Italian population

Abstract:
Fish and shellfish belonging to five different species among pelagic, benthonic and molluscs, were collected from the Gulf of Catania in 2017 to evaluate arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se) vanadium (V) and zinc (Zn). Risk of developing chronic systemic effects derived from seafood consumption was evaluated with the Target Hazard Quotient (THQ) and compared with the results obtained from the same area and the species, collected in 2012. Hg, Cd and Pb concentrations were found below the limits set by European Community for human consumption in all the analysed species. The total risk is reduced from 1.1 to 0.49, and this result is strongly associated with the lower bioaccumulations levels found for Hg, Mn, Se and V. Others metals such as As, Pb, Ni

and Zn bioaccumulation levels remain approximately the same, conversely, it is revealed a slight increase of Cd and Cr. Overall, the present study show a positive picture of the studied area, the Gulf of Catania, highlighting not only a decreased metal availability of the study area, but, above all, a decreased risk to develop chronic systemic effects derived from consumption of local seafood.

Espinosa-Zurutuza, M., Gonzalez-Villalva, A., Albarran-Alonso, J.C.*, et al.* (2018) Oxidative Stress as a Mechanism Involved in Kidney Damage After Subchronic Exposure to Vanadium Inhalation and Oral Sweetened Beverages in a Mouse Model. *International Journal of Toxicology,* 37(1): 45-52.
Keywords: inhalation; kidney; oxidative stress; sweetened beverages; vanadium

Abstract:
Kidney diseases have notably increased in the last few years. This is partially explained by the increase in metabolic syndrome, diabetes, and systemic blood hypertension. However, there is a segment of the population that has neither of the previous risk factors yet suffers kidney damage. Exposure to atmospheric pollutants has been suggested as a possible risk factor. Air-suspended particles carry on their surface a variety of fuel combustion-related residues such as metals, and vanadium is one of these. Vanadium might produce oxidative stress resulting in the damage of some organs such as the kidney. Additionally, in countries like Mexico, the ingestion of sweetened beverages is a major issue; whether these beverages alone are responsible for direct kidney damage or whether their ingestion promotes the progression of an existing renal damage generates controversy. In this study, we report the combined effect of vanadium inhalation and sweetened beverages ingestion in a mouse model. Forty CD-1 male mice were distributed in 4 groups: control, vanadium inhalation, 30% sucrose in drinking water, and vanadium inhalation plus sucrose 30% in drinking water. Our results support that vanadium inhalation and the ingestion of 30% sucrose induce functional and histological kidney damage and an increase in oxidative stress biomarkers, which were higher in the combined effect of vanadium plus 30% sucrose. The results also support that the ingestion of 30% sucrose alone without hyperglycemia also produces kidney damage.

Keil, D.E., Buck, B., Goossens, D.*, et al.* (2018) Nevada desert dust with heavy metals suppresses IgM antibody production. *Toxicology Reports,* 5: 258-269.
Keywords: Geogenic dust; Heavy metals; Particulate matter; Immunotoxicity; Neurotoxicity

Abstract:
Systemic health effects from exposure to a complex natural dust containing heavy metals from the Nellis Dunes Recreation Area (NDRA) near Las Vegas, NV, were evaluated. Several toxicological parameters were examined following lung exposure to emissive dust from three geologic sediment types heavily used for recreational off-road activities: yellow sand very rich in arsenic (termed CBN 5); a shallow cover of loose dune sand overlying a gravelly subsoil bordering dune fields (termed CBN 6); and brown claystone and siltstone (termed CBN 7). Adult female B6C3F1 mice were exposed by oropharyngeal administration to these three types of geogenic dusts at

0.01–100 mg of dust/kg of body weight, once per week for four weeks. The median grain sizes were 4.6, 3.1, and 4.4 µm, for CBN 5, 6, and 7, respectively. Each type of dust contained quantifiable amounts of aluminum, vanadium, chromium, manganese, iron, cobalt, copper, zinc, arsenic, strontium, cesium, lead, uranium, and others. Descriptive markers of immunotoxicity, neurotoxicity, hematology, and clinical chemistry parameters were assessed. Notable among all three CBN units was a systemic, dose-responsive decrease in antigen-specific IgM antibody responses. Geogenic dust from CBN 5 produced more than a 70% suppression in IgM responses, establishing a lowest adverse effect level (LOAEL) of 0.01 mg/kg. A suppression in IgM responses and a corresponding increase in serum creatinine determined a LOAEL of 0.01 mg/kg for CBN 6. The LOAEL for CBN 7 was 0.1 mg/kg and also was identified from suppression in IgM responses. These results are of concern given the frequent off-road vehicle traffic and high visitor rates at the NDRA, estimated at 300,000 each year.

Pérez, R., Doménech, E., Conchado, A.*, et al.* (2017) Influence of diet in urinary levels of metals in a biomonitoring study of a child population of the Valencian region (Spain). *Science of the Total Environment,* 618: 1647-1657.
Keywords: Biomonitoring; Children; Metals; Urine

Abstract:
Pollution by trace elements and its possible effect on organisms has become a worldwide concern due to the increasing presence of trace elements in the environment and especially in the food chain. Exposure to chemicals has traditionally been measured using environmental samples, however, human biomonitoring brings a different perspective, in which all sources and exposure pathways are integrated. The objective of this paper is to discern the possible relationship between children's diet and the metals found in children urine. With this aim in mind, a total of 120 voluntaries participated in a diet survey carried out in a school-aged population (age 6–11) from the Valencian region. In addition, twenty trace elements were analysed in children urine (arsenic, antimony, barium, beryllium, caesium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, platinum, selenium, thallium, thorium, uranium, vanadium and zinc). Results permitted to compare metal levels in urine with metal levels of other biomonitoring studies to conclude that values, including ours, were similar in most studies. On the other hand, children who ate more vegetables had the highest values in cadmium, copper, molybdenum, antimony, thallium, vanadium, and zinc, while those who ate more fish reached higher values in mercury. Finally, children who ate more cereals and baked products had higher values in total arsenic. ".

Rubio, C., Acosta, L., Luis-Gonzalez, G.*, et al.* (2018) A Limited Survey of Metal Content in Blue Jack Mackerel (Trachurus picturatus) Obtained from Markets in the Canary Islands. *Journal of Food Protection*, 81(2): 202-208.
Keywords: Dietary intake; Inductively coupled plasma optical emission spectrometry; Liver; Metals; Muscle; Trachurus picturatus

Abstract:

The levels of 20 metals (aluminum, boron, barium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, strontium, vanadium, and zinc) were analyzed in muscle and liver tissue of Trachurus picturatus marketed in the Canary Islands (Spain) by using inductively coupled plasma optical emission spectrometry. In the liver samples, the mean concentrations in milligrams per kilogram wet weight (wt) of Al (14.7), B (0.99), Ba (1.64), Ca (314), Cd (2.52), Co (0.15), Cu (4.07), Fe (106), Li (3.89), Mn (0.85), Mo (0.16), Na (1510), Ni (0.51), Pb (0.36), Sr (3.54), V (0.78), and Zn (23.13) were higher than those detected in the muscle samples in milligrams per killogram wet wt, which were as follows: Al (8.76), B (0.07), Ba (0.30), Ca (210), Cd (0.01), Co (0.01), Cu (1.51), Fe (7.33), Li (1.08), Mn (0.12), Mo (0.01), Na (697), Ni (0.11), Pb (0.04), Sr (1.45), V (0.01), and Zn (4.69). The mean concentrations of Cr, K, and Mg (0.14, 1,904, and 243 mg/kg wet wt, respectively) were higher in muscle than in liver (0.05, 1,333 and 236 mg/kg wet wt, respectively). The mean concentrations of Cd and Pb (0.01 and 0.04 mg/kg wet wt) in muscle did not exceed the maximum limits established by a European Commission regulation (0.1 mg of Cd/kg and 0.3 mg of Pb/kg, respectively). Considering a mean daily consumption of fish muscle for the adult population of 31.9 g/day published in the report on food consumption by the Spanish Ministry of Agriculture and Fisheries, Food and Environment, Mg made the highest contributions to the intake (2.58% for adult women of 60 kg and 2.22% for men of 70 kg), and the estimated intakes of Al (0.35 to 0.46 mg/day), Cd (0.55 to 0.74 mg/day) and Pb (1.66 to 5.53 mg/day) were below the respective established tolerable intakes. In conclusion, the results of this study show that the consumption of muscle from this benthopelagic species can be considered safe in terms of maximum legal limits, while consumption of liver is discouraged as a major source of exposure to toxic metals, such as Al, Cd, and Pb.

2. HEALTH EFFECTS

Bagirov, V., Kalaschnikov, V., Zaitsev, A.*, et al.* (2017) Reproductive Function in Purebred Arabian Stallions as Related to the Levels of Chemical Elements in Mane Hair Samples. *Sel'Skokhozyaistvennaya Biologiya,* 52(6): 1184-1193. [Russian]
Keywords: purebred horses; Arabian breed; stallion; profiles of mineral elements in the horse hair; reproductive function; sperm quality

Abstract:
In modern animal husbandry, along with the improvement of reproductive technologies, it is becoming increasingly important to restore the natural fertility of livestock, in particular breeding producers. Reproductive function is one of the most sensitive that reacts to changes in biogeochemical and environmental parameters. In this regard, research aimed at studying effects of the level of chemical elements in the body on reproductive function in stallions is rather important. The parameters of sperm quality depending on the level of chemical elements in hair sampled from mane were studied. In this work we used biomaterial of purebred Arabian stallions (*n* = 50) of the same biogeochemical province. Reproductive qualities of stallions were evaluated in relation to the pool of chemical elements rated by concentration in the

mane hair. All animals were grouped according to the levels of individual elements in hair (i.e. up to percentile 25, within the interval of percentiles 25-75 and above percentile 75). Also the quality of fresh and cryopreserved semen was estimated. Hair profiles was determined for 25 elements (Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, I, K, Li, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, Hg, Sr, V, Zn)by inductively coupled plasma atomic emission and mass spectrometry (ICP-AES and ICP-MS). Ejaculate was assessed for volume, concentration, total spermatozoa number, number of spermatozoa with progressive motility and semen viability. The validity of the differences was verified by Mann-Whitney U test. It has been found out that the mane hair analysis can be used to detect reduced fertility in stallions. Increase in average values of Sr to 4.19±0.12, Se to 0,559±0.015, B to 21.55±1.14 μg/g in hair results in decrease in number and activity of sperm and filtrate volume. Activity and survival of stallion spermatozoa after thawing was in inverse correlation with Pb and Sn pool in the body, as determined by element level in the mane hair. With the increase in the concentration of these elements to 0,806±0206 and 0,051±0.008 mg/g, the sperm activity declines after thawing by 3.8-7.7 % and survival by 26.4-29.5 %, respectively. Animals with copper, silicon and vanadium in hair less than that of percentile 25, had the most active sperm. The survival rate of fresh sperm was associated with V concentration in hair being the highest in animals with low levels of this mineral. Thus, the assay of mane hair mineral profile can be used in monitoring for timely correction of stallions' fertility.

Espinosa-Zurutuza, M., Gonzalez-Villalva, A., Albarran-Alonso, J.C.*, et al.* (2018) Oxidative Stress as a Mechanism Involved in Kidney Damage After Subchronic Exposure to Vanadium Inhalation and Oral Sweetened Beverages in a Mouse Model. *International Journal of Toxicology,* 37(1): 45-52.
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Peat, F., Coomber, R., Rana, A.*, et al.* (2018) Vanadium allergy following total knee arthroplasty. *BMJ Case Reports,* 2018: Art. no. 222092.

Abstract:
Allergic reactions to metals following joint arthroplasty represent a rare and poorly understood phenomenon. Much is still unknown regarding the natural history of this complication, and how it can best be prevented and managed. We present a case of a 68-year-old woman who underwent a left total knee arthroplasty for treatment of osteoarthritis. After an initial uneventful postoperative course, she developed a troublesome erythematous rash both around the incision site and over her trunk. Blood testing revealed no evidence of infection and clinically her prosthesis was functioning well. Skin patch testing revealed positive results for vanadium (+) and palladium (+). Her cutaneous symptoms are currently being managed conservatively and have shown a partial response to topical steroids. Revision surgery remains a long-

term treatment option should conservative therapy fail; however, it would require a custom-made prosthesis as no standard tibial component is free from vanadium.

Ścibior, A., Gołębiowska, D., Adamczyk, A.*, et al.* (2018) Evaluation of lipid peroxidation and antioxidant defense mechanisms in the bone of rats in conditions of separate and combined administration of vanadium (V) and magnesium (Mg). *Chemico-Biological Interactions,* 284: 112-125.

Keywords: Antioxidants; Bone; Interactions; Lipid peroxidation; Magnesium; Minerals; Rats; Vanadium

Abstract:

The impact of vanadium (V) and magnesium (Mg) applied as sodium metavanadate (SMV, 0.125 mg V/ml) and magnesium sulfate (MS, 0.06 mg Mg/ml) on oxidative stress markers in bone of male Wistar rats was investigated. Some of them were also measured in the liver, e.g. l-ascorbic acid (hepatic L-AA). Additionally, relationships between selected indices determined in bone were examined. SMV alone (Group II) did not significantly alter the level of TBARS and the activity of SOD, compared with the control (Group I), but it slightly reduced the GR activity (by 13%) and the L-AA level (by 15.5%). It also markedly lowered the activity of CAT and GPx (by 34% and 29%), and to some degree elevated the activity of GST (by 16%) and the hepatic L-AA level (by 119%). MS alone (Group III) decreased the TBARS level (by 49%), slightly lowered the L-AA concentration (by 14%), and reduced the SOD, GPx, and GR activities (by 31%, 40%, and 28%), but did not change the activity of CAT, compared with the control. Additionally, it elevated the GST activity (by 56%) and the hepatic L-AA level (by 40%). In turn, the SMV + MS combination (Group IV) reduced the TBARS level (by 38%) and the SOD, CAT, GPx, and GR activities (by 61%, 58%, 72%, and 40%) but elevated the GST activity (by 66%), compared with the control. The activity of SOD and GPx in the rats in Group IV was also reduced, compared with Group II (by 61% and 61%) and Group III (by 44% and 54%). In turn, the activities of CAT and GR were decreased, compared with Group III (by 55%) and Group II (by 31%), and the L-AA level was lowered, in comparison with Groups II and III (by 53% and 54%). Further, the concentration of V in the bone of rats in Groups II and IV increased, whereas the concentration of Mg decreased, compared with Groups I and III, in which the V and Mg levels dropped and were not altered, respectively, compared with Group I. The total content of Fe in the bone of rats in Groups II and IV increased, compared with Group III, in which the total Fe content did not change, compared with Group I. In turn, the total bone Cu content significantly decreased in the rats in Groups III and IV, compared with Groups I and II, whereas the total Zn content and the Ca concentration did not change markedly. The results provided evidence that the concentration of V used as SMV did not enhance LPO in bone, whereas Mg, at the selected level, markedly reduced LPO in this tissue. On the other hand, both elements administered separately and in combination disrupted the antioxidant defense mechanisms and homeostasis of some metals in bone tissue, which consequently may have contributed to disturbances in the balance in the activities of osteoblastic and osteoclastic cells, and thereby negatively affected bone health.

Squadrone, S., Brizio, P., Mancini, C.*, et al.* (2018) Altered homeostasis of trace elements in the blood of SCA2 patients. *Journal of Trace Elements in Medicine and Biology,* 47: 111-114.
Keywords: SCA2; Metals; Blood; Oxidative stress

Abstract:
Spinocerebellar ataxia type 2 (SCA2) is a neurological disorder characterized by cerebellar dysfunction. The possible association between metals and neurodegenerative diseases is under constant investigation, with particular focus on their involvement in oxidative stress and their potential role as biomarkers of these pathologies. Whole blood samples of SCA2 patients and of healthy individuals were subjected to multi-elemental analysis by inductively coupled plasma-mass spectrometry (ICP-MS). Reduced levels of manganese and copper were found in SCA2 patients, while zinc and vanadium concentrations were significantly higher in patients compared to controls. Copper, manganese and zinc are cofactors of many enzymes (such as superoxide dismutase, SOD) involved in the cellular antioxidant response, whereas vanadium is a transition metal able to produce reactive radicals. A marked decrease of the antioxidant response has been previously reported in SCA2 patients. We suggest that an unbalance of transitional elements in the blood may reflect altered antioxidant homeostasis in SCA2 patients and could constitute a future peripheral biomarker for this disease. In addition, we suggest a possible role of vanadium in the altered lipid metabolism of SCA2 patients. ".

3. BIOLOGICAL MECHANISMS

Azevedo, C.G., Correia, I., dos Santos, M.M.C.*, et al.* (2018) Binding of vanadium to human serum transferrin - voltammetric and spectrometric studies. *Journal of Inorganic Biochemistry,* 180: 211-221.
Keywords: Vanadium; Transferrin; Voltammetric studies; MALDI-TOF; SAXS; Binding constants

Abstract:
Previous studies generally agree that in the blood serum vanadium is transported mainly by human serum transferrin (hTF). In this work through the combined use of electrochemical techniques, matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) mass spectrometry and small-angle X-ray scattering (SAXS) data it is confirmed that both VIV and VV bind to apo-hTF and holo-hTF. The electrochemical behavior of solutions containing vanadate(V) solutions at pH=7.0, analyzed by using two different voltammetric techniques, with different time windows, at a mercury electrode, Differential Pulse Polarography (DPP) and Cyclic Voltammetry (CV), is consistent with a stepwise reduction of VV→VIV and VIV→VII. Globally the voltammetric data are consistent with the formation of 2:1 complexes in the case of the system VV-apo-hTF and both 1:1 and 2:1 complexes in the case of VV-holo-hTF; the corresponding conditional formation constants were estimated. MALDI-TOF mass spectrometric data carried out with samples of VIVOSO4 and apo-hTF and of NH4VVO3 with both apo-hTF and holo-hTF with V:hTF ratios of 3:1 are consistent with

the binding of vanadium to the proteins. Additionally the SAXS data suggest that both VIVOSO4 and NaVVO3 can effectively interact with human apo-transferrin, but for holo-hTF no clear evidence was obtained supporting the existence or the absence of protein-ligand interactions. This latter data suggest that the conformation of holo-hTF does not change in the presence of either VIVOSO4 or NH4VVO3. Therefore, it is anticipated that VIV or VV bound to holo-hTF may be efficiently up-taken by the cells through receptor-mediated endocytosis of hTF.

Bai, Y., Zhang, Y., Xiao, J.*, et al.* (2018) Oxovanadium phenanthroimidazole derivatives: synthesis, DNA binding and antitumor activities. *Transition Metal Chemistry,* 43(2): 171-183.

Abstract:
Four unsymmetrical oxovanadium phenanthroimidazole complexes, [VO(hntdtsc)(NPIP)] (1), [VO(hntdtsc)(CPIP)] (2), [VO(hntdtsc)(MEPIP)] (3) and [VO(hntdtsc)(HPIP)] (4) (hntdtsc = 2-hydroxy-1-naphthaldehyde thiosemicarbazone, NPIP = 2-(4-nitrophenyl)-imidazo[4,5-f]1,10-phenanthroline, CPIP = 2-(4-chlorphenyl)-imidazo[4,5-f]1,10-phenanthroline), MEPIP = 2-(4-methylphenyl)-imidazo[4,5-f]1,10-phenanthroline), HPIP = 2-(4-hydroxylphenyl)-imidazo[4,5-f] 1,10-phenanthroline), have been synthesized and characterized. Their DNA binding and antitumor activities were determined by biochemical methods. All four oxovanadium complexes can bind with CT-DNA by an intercalation model and can also cleave supercoiled plasmid DNA in the presence of H2O2. The antitumor properties and mechanism of the complexes have been analyzed by MTT assay, cell cycle analysis, apoptosis assay and Western blot analysis. The results showed that the free ligands and their corresponding complexes all possess antiproliferative activities with very low IC50 values against Hela, BIU-87 and SPC-A-1 cell lines. Complex 1, which has a strongly electron-withdrawing nitro group, exhibited the best antiproliferative activities. Complex 1 caused G0/G1 phase arrest of the cell cycle and induced apoptosis in Hela cells. Additionally, complex 1 attenuated the phosphorylation of extracellular signal-regulated kinases 1 and 2 (ERK1/2). This indicates that inhibition of the ERK1/2 signaling pathway may contribute to the antitumor effects of these complexes.

Gallardo-Vera, F., Tapia-Rodriguez, M., Diaz, D.*, et al.* (2018) Vanadium pentoxide increased PTEN and decreased SHP1 expression in NK-92MI cells, affecting PI3K-AKT-mTOR and Ras-MAPK pathways. *Journal of Immunotoxicology,* 15(1): 1-11.
Available at:
https://www.tandfonline.com/doi/full/10.1080/1547691X.2017.1404662
Keywords: IL-2; IL-2R; NK cells; PTEN; SHP1; Vanadium pentoxide; signaling pathway

Abstract:
Vanadium is an air pollutant that imparts immunosuppressive effects on NK cell immune responses, in part, by dysregulating interleukin (IL)-2/IL-2R-mediated JAK signaling pathways and inducing apoptosis. The aim of the present study was to evaluate effects of vanadium pentoxide (V2O5) on other IL-2 receptor-mediated signaling pathways, i.e. PI3K-AKT-mTOR and Ras-MAPK. Here, IL-2-independent NK-

92MI cells were exposed to different V2O5 doses for 24 h periods. Expression of PI3K, Akt, mTOR, ERK1/2, MEK1, PTEN, SHP1, BAD and phosphorylated forms, as well as caspases-3, -8, -9, BAX and BAK in/on the cells were then determined by flow cytometry. The results show that V2O5 was cytotoxic to NK cells in a dose-related manner. Exposure increased BAD and pBAD expression and decreased that of BAK and BAX, but cell death was not related to caspase activation. At 400 microM V2O5, expression of PI3K-p85 regulatory subunit increased 20% and pPI3K 50%, while that of the non-pPI3K 110alpha catalytic subunit decreased by 20%. At 200 muM, V2O5 showed significant decrease in non-pAkt expression ($p < 0.05$); the decrease in pAkt expression was significant at 100 muM. Non-pmTOR expression displayed a significant downward trend beginning at 100 muM. Expressions of pMEK-1/2 and pERK-1/2 increased substantially at 200 muM V2O5. No differences were found with non-phosphorylated ERK-1/2. PTEN expression increased significantly at 100 muM V2O5 exposure whereas pPTEN decreased by 18% at 25 muM V2O5 concentrations, but remained unchanged thereafter. Lastly, V2O5 at all doses decreased SHP1 expression and increased expression of its phosphorylated form. These results indicated a toxic effect of V2O5 on NK cells that was due in part to dysregulation of signaling pathways mediated by IL-2 via increased PTEN and decreased SHP1 expression. These results can help to explain some of the known deleterious effects of this particular form of vanadium on innate immune responses.

Irving, E. & Stoker, A.W. (2017) Vanadium Compounds as PTP Inhibitors. *Molecules (Basel, Switzerland),* 22(12): 2269.

Available at: http://www.mdpi.com/1420-3049/22/12/2269/pdf
Keywords: BMOV; PTP; cancer; diabetes; oxidovanadium; oxovanadium; protein tyrosine phosphatases; vanadate; vanadium

Abstract:
Phosphotyrosine signaling is regulated by the opposing actions of protein tyrosine kinases (PTKs) and protein tyrosine phosphatases (PTPs). Here we discuss the potential of vanadium derivatives as PTP enzyme inhibitors and metallotherapeutics. We describe how vanadate in the V oxidized state is thought to inhibit PTPs, thus acting as a pan-inhibitor of this enzyme superfamily. We discuss recent developments in the biological and biochemical actions of more complex vanadium derivatives, including decavanadate and in particular the growing number of oxidovanadium compounds with organic ligands. Pre-clinical studies involving these compounds are discussed in the anti-diabetic and anti-cancer contexts. Although in many cases PTP inhibition has been implicated, it is also clear that many such compounds have further biochemical effects in cells. There also remain concerns surrounding off-target toxicities and long-term use of vanadium compounds in vivo in humans, hindering their progress through clinical trials. Despite these current misgivings, interest in these chemicals continues and many believe they could still have therapeutic potential. If so, we argue that this field would benefit from greater focus on improving the delivery and tissue targeting of vanadium compounds in order to minimize off-target toxicities. This may then harness their full therapeutic potential.

Jiang, P., Liu, Q., Ni, Z.*, et al.* (2018) Primary study on the toxic mechanism of vanadyl trehalose in Kunming mice. *Regulatory Toxicology and Pharmacology,* 94: 1-7. Keywords: Vanadyl trehalose; Vanadium; Toxic mechanism; Kunming mice

Abstract:
Abstract It has been shown that vanadyl trehalose could lower blood glucose but show mild toxicity to the stomach and intestine in diabetic Kunming mice. We analysed antioxidant levels, pro-inflammatory cytokine expression, apoptosis factors and intestinal microflora alteration to explore the mechanism of vanadyl trehalose toxicity in Kunming mice. The results revealed that oral administration of vanadyl trehalose at tested dose caused significant changes in oxidative stress factor (MDA levels elevated but SOD and T-AOC decreased), expression of inflammatory factor (IL-1β, COX-2, TNF-α and iNOS increased), and apoptosis factor (Bcl-2/Bax decreased and caspase-3 increased), and intestinal microflora dysbiosis (the number of Enterobacteriaceae and Enterococcus increased and Lactobacillus and Bifidobacterium decreased) relative to the control of Kunming mice. These results suggest that the toxic mechanisms of vanadyl trehalose on the stomach and intestine likely involve activation of the oxidative stress system, increased inflammatory response, promotion of apoptosis and the disruption of the normal intestinal microflora.

Mukhtiar, M., Jan, S.U., Ullah, I.*, et al.* (2017) The role of Glutathione, Cysteine and D-Penicillamine in exchanging Palladium and Vanadium metals from albumin metal complex. *Pakistan Journal of Pharmaceutical Sciences,* 30(6(Supplementary)): 2405-2410. Available at: https://www.pubfacts.com/detail/29188777/The-role-of-Glutathione-Cysteine-and-D-Penicillamine-in-exchanging-Palladium-and-Vanadium-metals-from-albumin-metal-complex

Abstract:
Thiol groups are extensively present across biological systems being found in range of small molecules (e.g. Glutathione, Homo-cysteine) and proteins (e.g. albumin, haemo-globin). Albumin is considered to be a major thiol containing protein present in circulating Plasma. Albumin contains a single thiolate group located at cysteine-34(cys-34) at its active site. Albumin also binds a wide variety of metals and metals complexes at various sites around the protein. Usually heavy metals are preferentially attached with the thiol group of albumin. The binding of heavy metals at cys-34 provides a mechanism by which the residence time of potentially toxic species in the body can be increased. In this research we have assessed the oxidative modification of and metal binding capacity of cys-34 with heavy metals Palladium and Vanadium to investigate the ease with which it is possible to effect disulfide-thiol exchange at this sites/or remove a metal bound at this position. Both the metals were treated with albumin and then the albumin metals (Pd and V) complexes were treated with small thoil molecules like Glutathione, Cysteine and D-Penicillamine. Our finding showed that the albumin thiol group retained the metals with itself by forming some strong bonding with the Thiols group, it is concluded from this finding that if by chance both the metals enter the living system; strongly disturb the chemistry and physiological function of this bio-molecule.

Ścibior, A., Gołębiowska, D., Adamczyk, A.*, et al.* (2018) Evaluation of lipid peroxidation and antioxidant defense mechanisms in the bone of rats in conditions of separate and combined administration of vanadium (V) and magnesium (Mg). *Chemico-Biological Interactions,* 284: 112-125.
Keywords: Antioxidants; Bone; Interactions; Lipid peroxidation; Magnesium; Minerals; Rats; Vanadium

Abstract:
The impact of vanadium (V) and magnesium (Mg) applied as sodium metavanadate (SMV, 0.125 mg V/ml) and magnesium sulfate (MS, 0.06 mg Mg/ml) on oxidative stress markers in bone of male Wistar rats was investigated. Some of them were also measured in the liver, e.g. l-ascorbic acid (hepatic L-AA). Additionally, relationships between selected indices determined in bone were examined. SMV alone (Group II) did not significantly alter the level of TBARS and the activity of SOD, compared with the control (Group I), but it slightly reduced the GR activity (by 13%) and the L-AA level (by 15.5%). It also markedly lowered the activity of CAT and GPx (by 34% and 29%), and to some degree elevated the activity of GST (by 16%) and the hepatic L-AA level (by 119%). MS alone (Group III) decreased the TBARS level (by 49%), slightly lowered the L-AA concentration (by 14%), and reduced the SOD, GPx, and GR activities (by 31%, 40%, and 28%), but did not change the activity of CAT, compared with the control. Additionally, it elevated the GST activity (by 56%) and the hepatic L-AA level (by 40%). In turn, the SMV + MS combination (Group IV) reduced the TBARS level (by 38%) and the SOD, CAT, GPx, and GR activities (by 61%, 58%, 72%, and 40%) but elevated the GST activity (by 66%), compared with the control. The activity of SOD and GPx in the rats in Group IV was also reduced, compared with Group II (by 61% and 61%) and Group III (by 44% and 54%). In turn, the activities of CAT and GR were decreased, compared with Group III (by 55%) and Group II (by 31%), and the L-AA level was lowered, in comparison with Groups II and III (by 53% and 54%). Further, the concentration of V in the bone of rats in Groups II and IV increased, whereas the concentration of Mg decreased, compared with Groups I and III, in which the V and Mg levels dropped and were not altered, respectively, compared with Group I. The total content of Fe in the bone of rats in Groups II and IV increased, compared with Group III, in which the total Fe content did not change, compared with Group I. In turn, the total bone Cu content significantly decreased in the rats in Groups III and IV, compared with Groups I and II, whereas the total Zn content and the Ca concentration did not change markedly. The results provided evidence that the concentration of V used as SMV did not enhance LPO in bone, whereas Mg, at the selected level, markedly reduced LPO in this tissue. On the other hand, both elements administered separately and in combination disrupted the antioxidant defense mechanisms and homeostasis of some metals in bone tissue, which consequently may have contributed to disturbances in the balance in the activities of osteoblastic and osteoclastic cells, and thereby negatively affected bone health.

4. USES OF VANADIUM

Ahmadi-Eslamloo, H., Dehghani, G.A. & Moosavi, S.M.S. (2018) Long-term treatment of diabetic rats with vanadyl sulfate or insulin attenuate acute focal cerebral ischemia/reperfusion injury via their antiglycemic effect. *Metabolic Brain Disease,* 33(1): 225-235.

Keywords: Cerebral ischemia/reperfusion; Diabetes mellitus; Insulin; Middle cerebral artery occlusion; Reactive oxygen species; Vanadium

Abstract:
It is well-known that patients with diabetes mellitus have worse clinical outcomes following acute ischemic stroke. The intensifying effects of diabetes on ischemic brain injury have been shown to be mostly due to hyperglycemia, rather than the lack of insulin direct effects on brain. It is also well-approved that vanadium compounds have insulin-like and anti-diabetic effects, and the present study was designed to compare the protective effects of diabetes treatment with vanadium or insulin on ischemic/reperfused brain injury. Male Sprague-Dawley rats were divided into 4 groups (n = 21). Two groups of streptozotocin-induced diabetic rats were treated with either vanadyl sulfate or insulin at proper doses to similarly attenuate hyperglycemia during 45 days, while there was no treatment in the control diabetic and non-diabetic sham groups. Thereafter, all treated and non-treated diabetic rats were subjected to 60-min of the right middle cerebral artery occlusion followed by 12-h reperfusion, and then their brains were removed for evaluating blood-brain barrier leakage, tissue swelling, infarct size and oxidant status in both hemispheres. Vanadium and insulin that equally reduced blood glucose and water intake had some differences in their antidiabetic effects of ameliorating weight loss and hypertension during 45-days treatment period. However, they caused similar decrements in levels of Evans blue dye extravastion, edema, infarct volume and malondialdehyde in ischemic/reperfused cerebral hemisphere. Therefore, it can be suggested that insulin and vanadium via their antiglycemic effect cause reduction in cerebral production of oxidants following acute focal ischemia/reperfusion, which attenuate BBB disruption and brain tissue injury.

Crans DC, Yang L, Haase A and Yang X (2018) Health Benefits of Vanadium and Its Potential as an Anticancer Agent. In: Sigel A, Sigel E, Freisinger E and Sigel RKO (eds) *Metallo-Drugs: Development and Action of Anticancer Agents: Development and Action of Anticancer Agents.* Netherlands, 251-279

Abstract:
Vanadium compounds have been known to have beneficial therapeutic properties since the turn of the century, but it was not until 1965 when it was discovered that those effects could be extended to treating cancer. Some vanadium compounds can combat common markers of cancer, which include metabolic processes that are important to initiating and developing the phenotypes of cancer. It is appropriate to consider vanadium as a treatment option due to the similarities in some of the metabolic pathways utilized by both diabetes and cancer and therefore is among the few drugs that are effective against more than one disease. The development of vanadium compounds as protein phosphatase inhibitors for the treatment of diabetes may be useful for potential applications as an anticancer agent. Furthermore, the

ability of vanadium to redox cycle is also important for biological properties and is involved in the pathways of reactive oxygen species. Early agents including vanadocene and peroxovanadium compounds have been investigated in detail, and the results can be used to gain a better understanding of how some vanadium compounds are modifying the metabolic pathways potentially developing cancer. Considering the importance of coordination chemistry to biological responses, it is likely that proper consideration of compound formulation will improve the efficacy of the drug. Future development of vanadium-based drugs should include consideration of drug formulation at earlier stages of drug development.

Ferreira, N.H., Furtado, R.A., Ribeiro, A.B.*, et al.* (2018) Europium(III)-doped yttrium vanadate nanoparticles reduce the toxicity of cisplatin. *Journal of Inorganic Biochemistry,* 182: 9-17.

Keywords: Europium(III)-doped ytrrium vanadate; Inorganic nanoparticles; Cisplatin; Toxicity; Antitumor activity; Folic acid

Abstract:

The aim of this study was to evaluate the antitumor efficiency of chemotherapy with cisplatin alone and incorporated into europium(III)-doped yttrium vanadate nanoparticles functionalized with 3-chloropropyltrimethoxysilane with folic acid and without folic acid in a syngeneic mouse melanoma model. Histopathological, biochemical and genotoxic analyses of treated animals were performed to assess the toxicity of treatments. The treatment of the animals with cisplatin alone and the nanoparticles functionalized with cisplatin at a dose of 5 mg/kg b.w. for 5 days reduced tumor weight about 86% and 65%, respectively. Histopathological analysis showed lower mean frequency of mitoses in tumor tissue of the groups receiving cisplatin alone (90% reduction) and the nanoparticles functionalized with cisplatin (70% reduction) compared to the tumor control group. A reduction in body and liver weight and an increase in serum creatinine and urea levels were observed in animals treated with CDDP, but not in those receiving the nanoparticles functionalized with cisplatin. Genotoxicity assessment by the comet assay revealed lower frequencies of DNA damage in animals treated with the nanoparticles functionalized with cisplatin (mean score = 140.80) compared to those treated with cisplatin alone (mean score = 231.80). Marked toxic effects were observed in animals treated with cisplatin alone, while treatment with the nanoparticles functionalized with cisplatin showed no toxicity. Moreover, folic acid in the inorganic nanoparticles reduced the genotoxicity of cisplatin in the bone marrow micronucleus test (10 ± 1.4 and 40 ± 0.0 micronucleus, respectively). These results demonstrate the antitumor efficiency and significantly reduced systemic toxicity of the nanoparticles compared to CDDP.

Ippolito, J.A., Krell, E.S., Cottrell, J.*, et al.* (2017) Effects of local vanadium delivery on diabetic fracture healing. *Journal of Orthopaedic Research: Official Publication of the Orthopaedic Research Society,* 35(10): 2174-2180.

Keywords: Animals; Diabetes Mellitus, Experimental/complications; Drug Evaluation, Preclinical; Femoral Fractures/complications/diagnostic imaging/drug therapy; Fracture Healing/drug effects; Radiography; Rats, Wistar; Trace Elements/administration & dosage; Vanadium/administration & dosage; BB Wistar;

bone; cartilage; diabetes; fracture healing; insulin mimetic fracture healing; mechanical strength; vanadium

Abstract:
This study evaluated the effect of local vanadyl acetylacetonate (VAC), an insulin mimetic agent, upon the early and late parameters of fracture healing in rats using a standard femur fracture model. Mechanical testing, and radiographic scoring were performed, as well as histomorphometry, including percent bone, percent cartilage, and osteoclast numbers. Fractures treated with local 1.5 mg/kg VAC possessed significantly increased mechanical properties compared to controls at 6 weeks post-fracture, including increased torque to failure (15%; p = 0.046), shear modulus (89%; p = 0.043), and shear stress (81%; p = 0.009). The radiographic scoring analysis showed increased cortical bridging at 4 weeks and 6 weeks (119%; p = 0.036 and 209%; p = 0.002) in 1.5 mg/kg VAC treated groups. Histomorphometry of the fracture callus at days 10 and 14 showed increased percent cartilage (121%; p = 0.009 and 45%; p = 0.035) and percent mineralized tissue (66%; p = 0.035 and 58%; p = 0.006) with local VAC treated groups compared to control. Additionally, fewer osteoclasts were observed in the local VAC treated animals as compared to controls at day 14 (0.45% +/- 0.29% vs. 0.83% +/- 0.36% of callus area; p = 0.032). The results suggest local administration of VAC acts to modulate osteoclast activity and increase percentage of early callus cartilage, ultimately enhancing mechanical properties comparably to non-diabetic animals treated with local VAC. (c) 2017 Orthopaedic Research Society. Published by Wiley Periodicals, Inc. J Orthop Res 35:2174-2180, 2017.

Irving, E. & Stoker, A.W. (2017) Vanadium Compounds as PTP Inhibitors. *Molecules (Basel, Switzerland),* 22(12): 2269.
Available at: http://www.mdpi.com/1420-3049/22/12/2269/pdf
Keywords: BMOV; PTP; cancer; diabetes; oxidovanadium; oxovanadium; protein tyrosine phosphatases; vanadate; vanadium

Abstract:
Phosphotyrosine signaling is regulated by the opposing actions of protein tyrosine kinases (PTKs) and protein tyrosine phosphatases (PTPs). Here we discuss the potential of vanadium derivatives as PTP enzyme inhibitors and metallotherapeutics. We describe how vanadate in the V oxidized state is thought to inhibit PTPs, thus acting as a pan-inhibitor of this enzyme superfamily. We discuss recent developments in the biological and biochemical actions of more complex vanadium derivatives, including decavanadate and in particular the growing number of oxidovanadium compounds with organic ligands. Pre-clinical studies involving these compounds are discussed in the anti-diabetic and anti-cancer contexts. Although in many cases PTP inhibition has been implicated, it is also clear that many such compounds have further biochemical effects in cells. There also remain concerns surrounding off-target toxicities and long-term use of vanadium compounds in vivo in humans, hindering their progress through clinical trials. Despite these current misgivings, interest in these chemicals continues and many believe they could still have therapeutic potential. If so, we argue that this field would benefit from greater focus on improving the delivery

and tissue targeting of vanadium compounds in order to minimize off-target toxicities. This may then harness their full therapeutic potential.

Paulpandiyan, R. & Raman, N. (2017) Oxovanadium(IV) complexes with Knoevenagel Schiff base condensate as impending chemotherapeutic agents: Synthesis, characterization, biological screening and anti-proliferative assay. *Bioorganic Chemistry,* 73: 100-108.

Keywords: Antineoplastic Agents/chemical synthesis/chemistry/pharmacology; Apoptosis/drug effects; Cell Proliferation/drug effects; Coordination Complexes/chemical synthesis/chemistry/pharmacology; Dose-Response Relationship, Drug; Drug Evaluation, Preclinical; Drug Screening Assays, Antitumor; HeLa Cells; Humans; MCF-7 Cells; Molecular Structure; Schiff Bases/chemistry/pharmacology; Structure-Activity Relationship; Tumor Cells, Cultured; Vanadium Compounds/chemistry/pharmacology; Intercalative binders; MTT method; Oxidative cleavage; Oxovanadium(IV) complexes; Square pyramidal

Abstract:
Two novel oxovanadium(IV) complexes [VOL1]SO4(1) and [VOL2]SO4(2) containing Knoevenagel condensate Schiff base ligand (L1/L2) have been synthesized and characterized by physical, spectral and analytical methods. These complexes are reported as ionic in nature on the basis of elemental composition and molar conductance, and possess square pyramidal geometry around the central metal ions. The binding interactions of (1) and (2) with calf thymus DNA (CT DNA) were explored by absorption spectrophotometric titration, cyclic voltammetry data and viscosity measurements. The calculated intrinsic binding constant values (Kb) for (1) and (2) obtained from UV-Vis absorption studies are 0.4x10(5) and 5.6x10(5) (M(-1)) respectively. These experimental results indicate that (1) and (2) are intercalative binders and avid binder to CT DNA with different affinities. These complexes exhibit significant oxidative cleavage of supercoiled plasmid (pUC18) DNA in the presence of activators. In particular, the in vitro antimicrobial efficacy of oxovanadium(IV) complexes reveal that they are more active than free ligands. Besides, the in vitro cytotoxic effect of the titled complexes were examined on a bundle of human tumor cell lines such as MCF-7 and HeLa cancerous cell lines by the MTT method. Interestingly, complex (2) exhibits more potent cytotoxic activity than the other complex and standard drug (cisplatin). The mode of cell death was assessed by Hoechst 33258 staining morphological studies.

Peat, F., Coomber, R., Rana, A*., et al.* (2018) Vanadium allergy following total knee arthroplasty. *BMJ Case Reports,* 2018: Art. no. 222092.

Abstract:
Allergic reactions to metals following joint arthroplasty represent a rare and poorly understood phenomenon. Much is still unknown regarding the natural history of this complication, and how it can best be prevented and managed. We present a case of a 68-year-old woman who underwent a left total knee arthroplasty for treatment of osteoarthritis. After an initial uneventful postoperative course, she developed a troublesome erythematous rash both around the incision site and over her trunk.

Blood testing revealed no evidence of infection and clinically her prosthesis was functioning well. Skin patch testing revealed positive results for vanadium (+) and palladium (+). Her cutaneous symptoms are currently being managed conservatively and have shown a partial response to topical steroids. Revision surgery remains a long-term treatment option should conservative therapy fail; however, it would require a custom-made prosthesis as no standard tibial component is free from vanadium.

5. ENVIRONMENTAL EFFECTS in PLANTS and SOIL

Hu, X., Yue, Y. & Peng, X. (2018) Release kinetics of vanadium from vanadium titano-magnetite: The effects of pH, dissolved oxygen, temperature and foreign ions. *Journal of Environmental Sciences,* 64: 298-305.
Keywords: Vanadium; Release rate; Hydrogen ion; Dissolved oxygen

Abstract:
As part of a broader study of the environmental geochemistry behavior of vanadium (V), the release kinetics of V from the dissolution of natural vanadium titano-magnetite under environmentally relevant conditions was investigated. In both the acidic and basic domains, the V release rate was found to be proportional to fractional powers of hydrogen ion and dissolved oxygen activities. The dependence of the rate on dissolved oxygen can also be described in terms of the Langmuir adsorption model. The empirical rate equation is given by: r=k'αH+αKαO21+KαO2 where, α=0.099–0.265, k'=3.2×10−6–1.7×10−5, K=2.7×104–3.9×104mol/L in acid solution (pH4.1), and α=−0.494−(−0.527), k'=2.0×104–2.5×10−11, and K=4.1×103–6.5×103mol/L in basic solution (pH8.8) at 20°C. Based on the effect of temperature on the release rate of V, the activation energies of minerals at pH8.8 were determined to be 148–235kJ/mol, suggesting that the dissolution of vanadium titano-magnetite is a surface-controlled process. The presence of Na+, Ca2+, Mg2+, K+, NO3−, Cl−, SO42− and CO32− was found to accelerate the V release rates. This study improves the understanding of both the V pollution risk in some mine areas and the fate of V in the environment. ".

Shaheen, S.M. & Rinklebe, J. (2018) Vanadium in thirteen different soil profiles originating from Germany and Egypt: Geochemical fractionation and potential mobilization. *Applied Geochemistry,* 88: 288-301.
Keywords: Vanadium availability; Depth function of vanadium in soils; Sequential extraction procedure; Trace elements (TEs); Canonical discrimination analysis (CDA)

Abstract:
Knowledge about geochemical fractions of vanadium (V) in different soils is required to understand its potential mobilization which we assessed in thirteen soil profiles originating from Germany and Egypt using the sequential extraction technique of the Commission of the European Communities Bureau of Reference (BCR). The concentrations of total, AB-DTPA-extractable, and the geochemical fractions [acid soluble (F1), reducible (F2), oxidisable (F3), and residual (F4) fraction] of V in the soils were determined. The total V concentrations ranged from 20.7 to 133.1 mg kg−1 and correlated positively with clay content and the total concentrations of iron (Fet), aluminum (Alt), and manganese (Mnt). The total V was stronger affected by free Fe

and Mn oxides (Fed and Mnd) in the Egyptian soils than in the German soils. The residual fraction of V was dominant in the soils followed by the reducible and the oxidisable fraction and showed a similar behavior to total V. The reducible V was higher in the Egyptian soils than in the German soils and was positively correlated with Fet, Alt, Mnt, Fed, and Mnd. The impact of Fet, Alt, and Mnt on the reducible V was stronger in the Egyptian soils than in the German soils, while the impact of Fed and Mnd on the reducible V was stronger in the German soils than Egyptian soils. The oxidisable V was affected by soil organic matter and total sulphur (St) in the German soils and by carbonates and St in the Egyptian soils. The acid soluble fraction of V was lower than the detection limits in all soils. The AB-DTPA-extractable V concentrations (potential available V) ranged between 0.04 and 4.04 mg kg−1. The potential mobile fraction (PMF = ∑F1−F3) accounted 4.4–64.7% of the total V. The alkaline soils showed the highest potential mobility and availability of V compared to the acidic soils, and thus the AB-DTPA-extractable V correlated positively with soil pH as well as clay content, cation exchange capacity, and Fet. The reducible fraction contributed stronger to the potential mobility and availability of V than the oxidisable fraction. The canonical discrimination analysis explained 64% of the variability of the geochemical behavior of the different soil groups and showed that the different groups of soils could differentiate from each other. The German soil groups (Eutric Fluvisols, Calcic Luvisols, Tidalic Fluvisol and Haplic Gleysol (Marsh soils)), showed a different geochemical behavior; while the Egyptian Eutric Fluvisols and Sodic Fluvisols were relatively similar in their geochemical behavior and the Haplic Calcisols was relatively close to them. Our results demonstrate that the potential mobilization of V was high in the soils (except for Luvisols) - especially under alkaline conditions-which indicate a release of this toxic metal from the soils to soil solution. This release may cause potential environmental risks such as the transfer of V into the groundwater, the vegetation and food chain. Future studies should elucidate the temporal kinetics of V and the determining factors under different flooding conditions and remediation approaches are necessary to ameliorate V-contaminated soils.

6. ENVIRONMENTAL EFFECTS in TERRESTRIAL ORGANISMS

Pal, R.P., Mani, V., Tripathi, D.*, et al.* (2018) Influence of Feeding Inorganic Vanadium on Growth Performance, Endocrine Variables and Biomarkers of Bone Health in Crossbred Calves. *Biological Trace Element Research,* 182(2): 248-256.
Keywords: Biomarker; Bone health; Crossbred calves; Hormones; Performance; Vanadium

Abstract:
The nutritional essentialities of transition element vanadium (V) as micro-nutrient in farm animals have not yet been established, though in rat model, vanadium as vanadate has been reported to exert insulin-mimetic effect and shown to be needed for proper development of bones. The objective of this study was to determine the effect of V supplementation on growth performance, plasma hormones and bone health status in calves. Twenty-four crossbred calves (body weight 72.83 ± 2.5 kg; age

3–9 months) were blocked in four groups and randomly assigned to four treatment groups (n = 6) on body weight and age basis. Experimental animals were kept on similar feeding regimen except that different groups were supplemented with either 0, 3, 6 or 9 ppm inorganic V/kg DM. Effect of supplementation during 150-day experimental period was observed on feed intake, body weight gain, feed efficiency, body measures, endocrine variables, plasma glucose and biomarkers of bone health status. Supplementation of V did not change average daily gain (ADG), dry matter intake (DMI), feed efficiency and body measures during the experimental period. During the post-V supplementation period plasma insulin-like growth factor-1 (IGF-1), triiodothyronine (T3) and thyroxin (T4) concentrations were increased and observed highest in 9 mg V/kg DM fed calves; however, levels of insulin, glucose, parathyroid hormone (PTH) and calcitonin hormones remained similar among calves fed on basal or V-supplemented diets. Bone alkaline phosphatase (Bone-ALP) concentration was increased ($P < 0.05$); however, plasma protein tyrosine phosphatase (PTP) level decreased ($P < 0.05$) in 6 and 9 mg V/kg DM supplemented groups. Plasma hydroxyproline (Hyp) and tartrate-resistant acid phosphatase (TRAP) concentration were unchanged by V supplementation. Blood V concentration showed positive correlation with supplemental V levels. These results suggest that V may play a role in modulation of the action of certain endocrine variables and biomarkers of bone health status in growing crossbred calves.

7. ENVIRONMENTAL EFFECTS in AQUATIC ORGANISMS

Copat, C., Grasso, A., Fiore, M.*, et al.* (2018) Trace elements in seafood from the Mediterranean sea: An exposure risk assessment. *Food and Chemical Toxicology,* 115: 13-19.

Keywords: THQ; Risk; Seafood; Metals; Italian population

Abstract:

Fish and shellfish belonging to five different species among pelagic, benthonic and molluscs, were collected from the Gulf of Catania in 2017 to evaluate arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se) vanadium (V) and zinc (Zn). Risk of developing chronic systemic effects derived from seafood consumption was evaluated with the Target Hazard Quotient (THQ) and compared with the results obtained from the same area and the species, collected in 2012. Hg, Cd and Pb concentrations were found below the limits set by European Community for human consumption in all the analysed species. The total risk is reduced from 1.1 to 0.49, and this result is strongly associated with the lower bioaccumulations levels found for Hg, Mn, Se and V. Others metals such as As, Pb, Ni and Zn bioaccumulation levels remain approximately the same, conversely, it is revealed a slight increase of Cd and Cr. Overall, the present study show a positive picture of the studied area, the Gulf of Catania, highlighting not only a decreased metal availability of the study area, but, above all, a decreased risk to develop chronic systemic effects derived from consumption of local seafood.

Kulkarni, R., Deobagkar, D. & Zinjarde, S. (2018) Metals in mangrove ecosystems and associated biota: A global perspective. *Ecotoxicology and Environmental Safety,* 153: 215-228.
Keywords: Mangrove forests; Metal pollution; Biota; Bioavailability

Abstract:
Mangrove forests prevalent along the intertidal regions of tropical and sub-tropical coastlines are inimitable and dynamic ecosystems. They protect and stabilize coastal areas from deleterious consequences of natural disasters such as hurricanes and tsunamis. Although there are reviews on ecological aspects, industrial uses of mangrove-associated microorganisms and occurrence of pollutants in a region-specific manner, there is no exclusive review detailing the incidence of metals in mangrove sediments and associated biota in these ecosystems on a global level. In this review, mangrove forests have been classified in a continent-wise manner. Most of the investigations detail the distribution of metals such as zinc, chromium, arsenic, copper, cobalt, manganese, nickel, lead and mercury although in some cases levels of vanadium, strontium, zirconium and uranium have also been studied. Seasonal, tidal, marine, riverine, and terrestrial components are seen to influence occurrence, speciation, bioavailability and fate of metals in these ecosystems. In most of the cases, associated plants and animals also accumulate metals to different extents and are of ecotoxicological relevance. Levels of metals vary in a region specific manner and there is disparity in the pollution status of different mangrove areas. Protecting these vulnerable ecosystems from metal pollutants is important from environmental safety point of view.

Rubio, C., Acosta, L., Luis-Gonzalez, G.*, et al.* (2018) A Limited Survey of Metal Content in Blue Jack Mackerel (Trachurus picturatus) Obtained from Markets in the Canary Islands. *Journal of Food Protection*, 81(2): 202-208.
Keywords: Dietary intake; Inductively coupled plasma optical emission spectrometry; Liver; Metals; Muscle; Trachurus picturatus

Abstract:
The levels of 20 metals (aluminum, boron, barium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, strontium, vanadium, and zinc) were analyzed in muscle and liver tissue of Trachurus picturatus marketed in the Canary Islands (Spain) by using inductively coupled plasma optical emission spectrometry. In the liver samples, the mean concentrations in milligrams per kilogram wet weight (wt) of Al (14.7), B (0.99), Ba (1.64), Ca (314), Cd (2.52), Co (0.15), Cu (4.07), Fe (106), Li (3.89), Mn (0.85), Mo (0.16), Na (1510), Ni (0.51), Pb (0.36), Sr (3.54), V (0.78), and Zn (23.13) were higher than those detected in the muscle samples in milligrams per killogram wet wt, which were as follows: Al (8.76), B (0.07), Ba (0.30), Ca (210), Cd (0.01), Co (0.01), Cu (1.51), Fe (7.33), Li (1.08), Mn (0.12), Mo (0.01), Na (697), Ni (0.11), Pb (0.04), Sr (1.45), V (0.01), and Zn (4.69). The mean concentrations of Cr, K, and Mg (0.14, 1,904, and 243 mg/kg wet wt, respectively) were higher in muscle than in liver (0.05, 1,333 and 236 mg/kg wet wt, respectively). The mean concentrations of Cd and Pb (0.01 and 0.04 mg/kg wet wt) in muscle did not exceed the maximum limits established by a

European Commission regulation (0.1 mg of Cd/kg and 0.3 mg of Pb/kg, respectively). Considering a mean daily consumption of fish muscle for the adult population of 31.9 g/day published in the report on food consumption by the Spanish Ministry of Agriculture and Fisheries, Food and Environment, Mg made the highest contributions to the intake (2.58% for adult women of 60 kg and 2.22% for men of 70 kg), and the estimated intakes of Al (0.35 to 0.46 mg/day), Cd (0.55 to 0.74 mg/day) and Pb (1.66 to 5.53 mg/day) were below the respective established tolerable intakes. In conclusion, the results of this study show that the consumption of muscle from this benthopelagic species can be considered safe in terms of maximum legal limits, while consumption of liver is discouraged as a major source of exposure to toxic metals, such as Al, Cd, and Pb.

8. MISCELLANEOUS

Faboya, O.L., Ojo, A.A., Bello, H.*, et al.* (2018) Geochemical investigation of trace elements in crude oils from two different depobelts in the Niger Delta basin, Nigeria. *Petroleum Science and Technology,* 36(2): 130-135.

Abstract:
The concentrations of trace elements in crude oil samples from the Northern and Central swamps depobelts in the Niger Delta basin were investigated using Flame Atomic Absorption Spectrometer. The origin, source facies, and depositional environment of organic matter that produced the oils were determined based on the trace elements concentrations. The concentrations of the trace elements (Cr, Cu, Fe, Mn, Ni and V) ranged from 0.04 to 5.71 ppm. Iron is the most abundant element in the samples while Cr has the least concentration. The results from trace metal geochemistry showed that the Niger Delta oils were derived predominantly from terrestrial organic matter deposited in the oxic depositional environment. The concentrations and ratios of nickel and vanadium grouped the oils into two distinct families reflecting the depobelt the oils belong. This observation indicates that the source rocks in the two depobelts were formed from organic matter of different source facies.

Kumar, S., Syed, A., Andotra, S.*, et al.* (2018) Investigation of synthesized new vanadium(III) complexes of ditolyldithiophosphate ligands by spectroscopic, cyclic voltammetric, DFT, antimicrobial and cytotoxic studies. *Journal of Molecular Structure,* 1154: 165-178.
Available at:
https://www.researchgate.net/publication/46256452_Synthesis_Characterization_and_Biocidal_Activities_of_Some_Schiff_Base_Metal_Complexes
Keywords: Vanadium; Dithiophosphate; Phosphorus; Sulfur; Antimicrobial; HOMO-LUMO

Abstract:
Vanadium(III) complexes with sulfur donor dithiophosphate ligands corresponding to [{(ArO)2PS2}3V] and [{(ArO)2PS2}2VCl.L] (Ar = o-, m-, p-CH3C6H4 and p-Cl-m-CH3C6H3; L = NC5H5, P(C6H5)3, have been synthesized and characterized by various

physico-chemical techniques like elemental analyses, magnetic studies, ESI-Mass, IR, UV and heteronuclear NMR (1H, 13C and 31P) spectral studies. These analyses have contributed to the prediction of structure: by exhibiting significant v(P-S) and v(PS) band shifting in comparative IR spectra; shifting of resonance signal in comparative 31P NMR spectra of ligands and complexes and stability of V(III) ion in the complexed state is confirmed by magnetic and UV studies. Therefore, the six coordinated geometry stabilizing the trivalent vanadium atom in the complexes and adducts, respectively has been confirmed. The cyclic voltammetric analyses presented the redox aptitude of the complex under analysis which can be utilized as catalyst in organic synthesis. The geometry of ligands and complexes has been optimized using density functional theory (DFT). The structural parameters, vibrational bands and energy gaps of frontier orbitals (HOMO–LUMO) have also been calculated. The calculated geometric and spectral results reproduced the experimental data with well agreement. The DFT computed frontier molecular orbitals (HOMO–LUMO) and their energies suggest charge transfer occurs within the complexes. Antimicrobial screening of the complexes against two bacterial strains: Gram–positive, Enterrococcus faecalis and Gram–negative, Eischerichia coli and fungus Fusarium oxysporum have shown potential bioactivity. A preliminary cytotoxic analysis has been carried out using the cultivated human cell lines: lung adeno carcinoma cell line A-549, leukemia cell line THP-1, prostate cancer cell line PC3 and colorectal cancer cell line HCT-116. ".

Pereira, T.L., Wallner-Kersanach, M., Costa, L.D.F.*, et al.* (2018) Nickel, vanadium, and lead as indicators of sediment contamination of marina, refinery, and shipyard areas. *Environmental Science and Pollution Research International,* 25(2): 1719-1730.

Keywords: Aluminum; Antifouling paints; Lead; Nickel; Petroleum products; Sediment; Shipyards; Vanadium

Abstract:
Metallic elements found in the aquatic environment may originate in areas where petroleum is refined and vessels are maintained and repaired. This study aims to assess contamination caused by nickel (Ni), lead (Pb), and vanadium (V) in sediment of the Lagoa dos Patos estuary (RS, Brazil) and to evaluate them as indicators of areas under the influence of petroleum products and antifouling paints. Surface sediments were collected in summer and in winter in areas of marinas, shipyards, refinery, and a control station. High Pb and V concentrations in shipyards and at the Yacht Club showed that some organisms may be affected by toxicity. High Pb results of the index of geoaccumulation (Igeo) were found at the Yacht Club and shipyards. Al, Ni, and V had similar distribution in the sediment in both seasons. Ni and V had high relation in winter at the Yacht Club and at the Santos Shipyard, thus suggesting that these elements come mainly from petroleum products. The same happened to the relations between Pb and V, as well as Pb and Ni at the Santos Shipyard. These elements are employed as useful tools as indicators to identify places with moderate to high localized anthropogenic inputs of petroleum derivatives and antifouling paints.

Schlesinger, W.H., Klein, E.M. & Vengosh, A. (2017) Global biogeochemical cycle of vanadium. *Proceedings of the National Academy of Sciences of the United States of America,* 114(52): E11092-E11100.
Available at:
http://sites.nicholas.duke.edu/avnervengosh/files/2017/12/PNAS-2017-Global-biogeochemical-cycle-of-vanadium.pdf
Keywords: aerosols; geochemical cycle; petroleum; rock weathering; vanadium

Abstract:
Synthesizing published data, we provide a quantitative summary of the global biogeochemical cycle of vanadium (V), including both human-derived and natural fluxes. Through mining of V ores (130 x 10(9) g V/y) and extraction and combustion of fossil fuels (600 x 10(9) g V/y), humans are the predominant force in the geochemical cycle of V at Earth's surface. Human emissions of V to the atmosphere are now likely to exceed background emissions by as much as a factor of 1.7, and, presumably, we have altered the deposition of V from the atmosphere by a similar amount. Excessive V in air and water has potential, but poorly documented, consequences for human health. Much of the atmospheric flux probably derives from emissions from the combustion of fossil fuels, but the magnitude of this flux depends on the type of fuel, with relatively low emissions from coal and higher contributions from heavy crude oils, tar sands bitumen, and petroleum coke. Increasing interest in petroleum derived from unconventional deposits is likely to lead to greater emissions of V to the atmosphere in the near future. Our analysis further suggests that the flux of V in rivers has been incremented by about 15% from human activities. Overall, the budget of dissolved V in the oceans is remarkably well balanced-with about 40 x 10(9) g V/y to 50 x 10(9) g V/y inputs and outputs, and a mean residence time for dissolved V in seawater of about 130,000 y with respect to inputs from rivers.

Sugiyama, I. & Williams-Jones, A.E. (2018) An approach to determining nickel, vanadium and other metal concentrations in crude oil. *Analytica Chimica Acta,* 1002: 18-25.
Keywords: Crude oil; Nickel; Vanadium; Ashing; Acid digestion; Inductively coupled plasma mass spectrometry

Abstract:
The ability to accurately determine the metal content of crude oils is necessary for reasons ranging from the need to identify the source of the oils (Ni and V) to removing components that might inhibit catalysis during refining or impact negatively on the environment during hydrocarbon combustion. Here we show that ashing followed by chemical oxidation and acid digestion, coupled with ICP-MS analysis, provides an accurate method for determining the concentration of metals in crude oil. Nickel and vanadium concentrations were measured in certified Ni and V oil standards and in various light, intermediate and heavy crude oils after application of a single vessel ashing-chemical oxidation-acid digestion sample preparation and storing technique. Prior to the ashing, chemical oxidation and acid digestion, an aliquot of the crude oil was placed in a 10 ml Pyrex™ culture tube and capped with quartz wool. The capped culture tubes were then subjected to thermal combustion, followed by chemical

oxidation and leaching. The leachates and the aqueous standards were diluted and analyzed for their Ni and V contents using inductively coupled plasma mass spectrometry (ICP-MS). The measured concentrations of Ni in oil standards, reported to contain 1, 100, and 1000 mg kg−1 Ni (±2% error), were 1.1 ± 0.01, 99.8 ± 1.46, and 1025 ± 24 mg kg−1 respectively. The corresponding concentrations of V in these standards, reported to contain 2, 100, and 1000 mg kg−1 V, were measured to be 1.93 ± 0.06, 104 ± 1.3, and 1027 ± 7.5 mg kg−1, respectively. Crude oil samples, A, B, C, D and E, that varied significantly in their composition, and ranged from light to heavy, were determined to contain 5.59 ± 0.32, 4.05 ± 0.03, 6.22 ± 0.22, 33.8 ± 0.7 and 41.6 ± 3.5 mg kg−1 Ni, respectively. Their V contents were determined to be 11.98 ± 0.1, 12.2 ± 0.1, 16.5 ± 0.4, 34.7 ± 0.4, and 104 ± 8.9 mg kg−1, respectively. The results were thus repeatable on average to 4.1% and 2.75% for Ni and V, respectively; the repeatability was worst (~8.5%) for crude oil E, a heavy (viscous) oil with a very high asphaltene content (27.2%). This modified single vessel ashing-digestion technique (combustion, chemical oxidation, acid leaching and storing) minimizes contamination and significantly reduces the loss of ash. Our results are repeatable, comparable to, and in some cases superior to those of other methods. The method is applicable to a wide range of crude oil compositions, is very accessible and robust, easy to use, and does not require costly equipment in preparing the samples for analysis by ICP-MS. ".

Zhan, G., Ng, W.C., Lin, W.Y.*, et al.* (2018) Effective Recovery of Vanadium from Oil Refinery Waste into Vanadium-Based Metal-Organic Frameworks. *Environmental Science & Technology,* 52(5): 3008-3015.

Abstract:
Carbon black waste, an oil refinery waste, contains a high concentration of vanadium (V) leftover from the processing of crude oil. For the sake of environmental sustainability, it is therefore of interest to recover the vanadium as useful products instead of disposing of it. In this work, V was recovered in the form of vanadium-based metal-organic frameworks (V-MOFs) via a novel pathway by using the leaching solution of carbon black waste instead of commercially available vanadium chemicals. Two different types of V-MOFs with high levels of crystallinity and phase purity were fabricated in very high yields (>98%) based on a coordination modulation method. The V-MOFs exhibited well-defined and controlled shapes such as nanofibers (length: >10 m) and nanorods (length: ~270 nm). Furthermore, the V-MOFs showed high catalytic activities for the oxidation of benzyl alcohol to benzaldehyde, indicating the strong potential of the waste-derived V-MOFs in catalysis applications. Overall, our work offers a green synthesis pathway for the preparation of V-MOFs by using heavy metals of industrial waste as the metal source.