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Chulabhorn Research Institute

INTERNATIONAL CENTRE FOR ENVIRONMENTAL AND INDUSTRIAL TOXICOLOGY (ICEIT)

CRI's ICEIT has been designated as a
"UNEP Centre of Excellence for Environmental and Industrial Toxicology".

INTER-UNIVERSITY POST-GRADUATE EDUCATION PROGRAM IN ENVIRONMENTAL TOXICOLOGY, TECHNOLOGY AND MANAGEMENT

A joint program between Chulabhorn Research Institute (CRI), Mahidol University (MU) and Asian Institute of Technology (AIT), has been conducted successfully since it was first launched in 1999.

The renewal of the agreement on the management of the program was signed on December 22, 2008 to continue the aim of the joint program which is to facilitate and foster academic cooperation between CRI, MU and AIT in offering an inter-university post-graduate education program leading to jointly-conferred Master's and Doctoral degrees in the field of "Environmental Toxicology, Technology and Management".

The signing ceremony was graciously presided over by Her Royal Highness Princess Chulabhorn, President of CRI, who signed on behalf of CRI, with Clinical Professor Piyasakol Sakolsata-yadorn, President of MU and Professor Said Irandoust, President of AIT signing for their respective institutions.

The curriculum of the post-graduate program in Environmental Toxicology, Technology and Management has been

(Continued on page 8)

Environmental, Social and Economic Implications of Global Reuse and Recycling of Personal Computers

A recent study explores the environmental, social, and economic aspects of a particular international reverse supply chain: reuse and recycling of computers. Computers are an important component of the growing volumes of end-of-life electronics, also known as e-waste. Disposal of used computers in the United States and other developed countries is increasing. These computers are resold, sent to landfills, recycled domestically, or shipped abroad for reuse and recycling. While precise estimates remain elusive, a significant portion of end-of-life computers go abroad and are recycled by an informal or "backyard" industry. A primary reason that so little is known about the industry is that sales and trade-in used electronics is invisible to the statistics collection systems of most nations. Informal electronics recycling activities have been documented in many parts of the world, including Guiyu and Wenqiao in China, Bangalore, Chennai, Delhi, and New Delhi in India, Lagos in Nigeria, and Karachi in Pakistan. These reports indicate serious environmental implications of informal recycling.

Computers contain toxic substances such as lead, mercury, and arsenic. While these toxins are embedded inside the computer and separated from the user during operation, concerns have been raised regarding the environmental risk associated with the potential for toxic substances to leach or otherwise be emitted from personal computer equipment when disposed of in landfills. Current policies often target recycling as a preferable alternative to landfilling.

But is recycling actually environmentally preferable to putting e-waste in sanitary landfills? This is not known and it is conceivable that recycling could emit more toxic heavy metals over the lifecycle. Recycling by definition mobilizes materials (e.g., via smelting) and depending on the level of process control can emit lead, mercury, and other hazardous substances. In contrast with landfills, however, recycling has the virtue of replacing production of virgin materials with recycled substitutes. If the avoided lead emissions associated with mining and milling are larger than for recycling, recycling would reduce total lead emissions. If not, recycling e-waste has the potential to release more lead to the environment than e-waste in landfills. At the time this study was undertaken, no analyses were available addressing which option (recycle versus landfill) leads to lower lifecycle emissions of heavy metals and under what circumstances. This question should be studied before public policy mandates recycling as the default environmentally preferable alternative.

Informal recycling of e-waste in developing nations has come under increasing public scrutiny. Studies by NGOs such as the Basel Action Network, the Silicon Valley Toxics Coalition, and Toxics Link argue that home-grown computer reuse/recycling systems in China, India, and Nigeria are causing serious environmental problems. For example, wires are pulled from computers, collected, and burned in open piles to remove casings and recover copper. Circuit boards are treated to extract copper and precious metals using acid, cyanide, and/or mercury, sometimes next to rivers.

There is an increasing body of scientific evidence confirming that the emissions and contamination associated with informal electronics recycling are indeed a serious concern. Researchers have undertaken field measurements of concentrations of metal and organics in ground, water, and air in Guiyu, China, the most well-known center of informal electronics recycling.

The release of heavy metals to water, for example, is thought to be mainly due to acid leaching of circuit boards next to the nearby Lianjiang and Nanyang rivers. Open combustion of equipment produces and emits dioxins, furans, and PAHs. In addition, the high degree of air emissions of PCDD/F and PBDD/F from open combustion of e-waste has been corroborated in laboratory simulations of the processes.

Furthermore, studies have begun to explore human exposure to hazardous pollutants emerging from Guiyu's recycling activities. Measurements of blood lead levels were taken for children under 6 years old and compared to levels in Chendian, a textile industry town with no e-waste recycling industry, located to the southwest of Guiyu. Results were that children in Guiyu clearly had higher blood lead levels. A sample of 165 Guiyu children had lead levels from 4.4 to 33 µg/dL with 80% exceeding 10 µg/dL, while a sample of 61 Chendian children showed a range of 4.0 to 23 µg/dL with 38% exceeding 10 µg/dL. Blood lead levels exceeding 10 µg/dL are considered of concern by the U.S. Center for Disease Control and Prevention. While further work is needed, these initial studies suggest that the environmental impacts of informal recycling are the most significant of human health impacts associated with the lifecycle of information and communication technology equipment.

Source: Environmental Science & Technology, Vol. 42, Issue 17, September 2008.

THE EFFECT OF CADMIUM EXPOSURE ON BLOOD PRESSURE

A recent study has examined the effect of cadmium exposure on blood pressure in the Korean population with in total 2000 participants aged 20 years or more.

The International Agency for Research on Cancer has classified cadmium as a human carcinogen. Cadmium has been reported to have cumulative effects on mortality, cardiovascular, neurologic, renal, and developmental diseases.

In animal studies, long-term high-level cadmium exposure has been shown to increase blood pressure. In occupational studies, a positive effect on blood pressure was found among cadmium workers. In the general population, however, conflicting results have been reported; while a positive association between cadmium exposure and blood pressure has been described in a few studies, no association or even a negative association has been also suggested.

Chronic cadmium exposure, once taken up, ends up to accumulate in liver, kidneys, and bone. Cadmium in liver moves to kidneys where it is excreted and then re-absorbed almost entirely. This poor ability of humans to excrete cadmium through kidneys underlies the health implications of cadmium as a nephrotoxin. In long-term high-exposure cases, the hypertension has been understood to arise secondary to the loss of kidney function. A number of active genes in the kidney are related to the control of blood pressure in physiologic state, however, including those affecting salt excretion and reabsorption, vascular tone, and volume homeostasis, and it is plausible that even low-level exposure to cadmium may affect the blood pressure control of the human body. However, few studies supported the role of cadmium-induced nephropathy including tubular damage, which might induce increase of blood pressure in part. If the kidney's role in the control of blood pressure is affected by cadmium, then the kidney function may act as an effect modifier on the association between cadmium exposure and hypertension. This study tried to examine the association between relatively low-level blood cadmium and physiologic control of blood pressure among a general population of Korea. It also examined the role of kidney function as an effect modifier on the influence of cadmium exposure on blood pressure.

In previous studies, the effect of cadmium exposure on blood pressure among a general population was inconsistent. However, the present study in the Korean population observed a consistent and dose-related elevation of systolic, diastolic, and mean arterial blood pressures and risk of hypertension with the increase in blood cadmium.

The fact that the cadmium level in this study population was rather high compared with previous studies may explain the difference in the consistency of findings; the mean blood cadmium of the subjects without and with hypertension was 1.64 μg/L (14.6 nmol/L) and 1.77 μg/L (15.7 nmol/L), respectively.

In this study, the cadmium level in blood was considerably higher. Cadmium is released into the environment mainly through industrial activities including non-ferrous metal production, waste incineration and fertilizer production. However, cadmium release and uptake through daily activities of the general population is rather limited in Korea, and it was suspected that the dietary cadmium intake, mainly through consumption of rice from cadmium contaminated environment, contributed to the high level of blood cadmium in this population together with smoking and other environmental exposures.

The exact biological mechanisms that link cadmium exposure with blood pressure increase and hypertension are uncertain. The primary mechanism may be related to the nephrotoxicity of cadmium. The major route of cadmium exposure is the gastrointestinal (GI) tract and respiratory system; the absorption rate is relatively higher via pulmonary route than via GI, and deposition, toxicity, target organ, and target tissue can differ. The liver detoxifies cadmium by combining it with glutathione (GSH) and excretes it in the bile; it can also be bound to metallothionein (MT). Cadmium is a redox-inactive metal and can deplete GSH and disrupt sulfhydryl homeostasis, which produces oxidative stress and lipid peroxidation. Cadmium-induced oxidative stress can damage kidney proteins, including Na^+/K^+ ATPase, and in return, a reduction in the activity of Na^+/K^+ ATPase can raise the blood pressure in rats after cadmium treatment. Most of the cadmium in plasma is bound to proteins, including albumin, GSH, MT, and other high- or low-molecular-weight proteins. Cadmium-metallothionein complex (Cd-MT) is filtered through glomerular membrane and transported to renal tubular cells from blood. The filtered Cd-MT is rapidly and completely re-absorbed and accumulated in the kidney, particularly in the proximal renal tubule in the cortex. In renal cells, Cd-MT enters the lysosomes, which release the cadmium into the cytosol and degrade the MT into amino acids. Cadmium not bound to MT can injure the renal tubules. This effect on renal tubular function can induce salt retention and volume overload, and eventually hypertension. The cadmium-induced kidney toxicity can proceed concurrently through renal tubular and glomerular damages even with a low environmental exposure level. Other potential mechanisms involve the increased activity of the renin-angiotensin system, monoamine oxidase, the vasodilator nitric oxide, agonism for calcium channels, and direct vasoconstrictor action.

A recent study found that the effect of blood cadmium on blood pressure was stronger among never smokers than current or former smokers. However, the Korean study found the effects among smokers stronger than never smokers. The cadmium level was considerably higher among current smokers than never smokers, and it was thought that the higher cadmium level was responsible for the stronger and significant effects of cadmium among smokers.

In this study, a single measurement of blood cadmium was used as the proxy dose for the integrated effect of cadmium on blood pressure over time. However, the current blood cadmium level cannot differentiate the contributions of current exposure, cumulative exposure, and internal deposits, such as the liver, kidneys, and bone. Given the non-

(Continued on page 7)

HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO TRANSITION METAL NANOMATERIALS

Transition metal nanomaterials are finding more applications in a number of industrial processes and consumer products. Iron nanoparticles are used in medical imaging, media storage, and in fluid applications, as well as for environmental remediation. Copper nanoparticles are used as sensors, catalysts and as additives in lubricant oils. Human exposure to these transition metal nanomaterials may occur in the manufacturing process as well as during handling, transport and use. Thus, investigations are needed to determine if there are harmful health effects associated with exposure.

The study described here is designed to compare toxicity of two commonly used commercially available, transition metal nanoparticles in inhalation studies.

In the current study, an integrated approach was used to examine the pulmonary inflammatory responses of two different types of inhaled transition metal nanoparticles in mice. In particular, mice were exposed to copper and iron nanoparticles with a manufacturer's reported average particle size of 25 nm and, according to manufacturer's specifications, these nanoparticles have been partially passivated with oxygen to form an oxide surface coating. A relative comparison of nanoparticle toxicity was conducted using acute and sub-acute exposures in a whole body chamber. Bronchoalveolar lavage (BAL) fluid cellularity, total protein, lactate dehydrogenase (LDH) activity and cytokines as well as lung histopathology were evaluated to assess responses. In addition, these nanoparticles were fully characterized using bulk and surface techniques to better understand their physicochemical properties. Dissolution studies of nanoparticles in two artificial biological fluids were conducted to better understand pulmonary effects of metal nanoparticles and how they are processed once they are inhaled and retained in the lungs.

The toxicity of inhaled iron or copper nanoparticles were tested in healthy mice using acute and sub-acute inhalation models.

These two different transition metal nanoparticles were fully characterized using bulk and surface methods. Although both nanoparticles were reported by the manufacturer to have average particle sizes of 25 nm, the copper nanoparticles were found to be approximately half the reported value but had a very narrow distribution.

The iron nanoparticles were measured to be 25 2 nm. Despite these differences in nanoparticle primary size, nanoparticle agglomerates were of comparable size with geometric mean mobility diameters between 187 and 200 nm.

Both metal nanoparticles were passivated with oxygen in the manufacturing process and x-ray diffraction (XRD) patterns of the iron and copper nanoparticles showed the presence of three distinct phases. X-ray photoelectron spectroscopy (XPS) data provided spectral evidence for an outermost surface coating of the most oxidized phase, γ-Fe_2O_3 and CuO, for iron and copper nanoparticles, respectively. Both nanoparticles have a concentration gradient of oxidation from a core of reduced metal to a layer of a partially oxidized phase to a surface layer of a completely oxidized phase. It is important to understand the structural make up of the particles because the surface-cellular interactions will play a key role in the biological response and chemical properties, e.g., the solubility will depend on surface composition and surface reactivity.

The results of the murine exposures show the copper nanoparticles to be significantly more toxic than iron nanoparticles. For the sub-acute exposure, there was a greater inflammatory response for copper than iron nanoparticles in mice necropsied immediately after exposure as evidenced by higher numbers of macrophages and neutrophils, higher concentration of total protein, increased LDH activity, elevation of a large number of cytokines and histopathological evidence. In the iron exposure, only a small number of neutrophils (200-fold less than copper) were present in the BAL fluid in mice necropsied immediately after exposure indicating the presence of less inflammation.

The study concluded that copper nanoparticles induced a greater inflammatory response based on neutrophilia, macrophages and total cell count from the BAL fluid as well as an increase in almost all cytokine levels measured when compared to the iron nanoparticles in the sub-acute studies.

Histopathology of the lungs 0 and 3 weeks post exposure showed no presence of copper whereas iron was found accumulating in macrophages. *In vitro* dissolution studies showed a greater propensity of copper to dissolve in the biological fluid increasing ion concentration and concomitantly decreasing the size of the nanoparticles. The increased inflammatory response of copper in the mouse model is proposed to be associated with the nanoparticle size and increased ion concentration produced from the dissolving nanoparticles *in vivo*.

Source: Nanotoxicology, Vol. 2, Issue 4, December 2008.

Susceptibility of Adults with Diabetes to Exposure to Ambient Fine Particles

Numerous epidemiologic studies have reported associations between exposure to ambient levels of particulate matter (PM) and various indices of acute cardiopulmonary morbidity and mortality. Ambient PM exposure at current levels has been implicated in the onset and exacerbation of lung and heart diseases. Although the primary mode of entry into the body is through the respiratory system, the greatest population-attributable risk from air pollution is due to cardiovascular disease.

Epidemiologic data suggest that individuals with diabetes may be at higher risk from effects of PM. Several parallels exist between the pathophysiologic effects of diabetes and the cardiovascular, hematologic, and autonomic responses to airborne PM. Moreover, evidence indicates that diabetes and insulin resistance are associated with endothelial dysfunction, which suggests that people with diabetes may be particularly susceptible to the effects of PM.

Flow-mediated dilatation (FMD) of the brachial artery is a noninvasive method of assessing endothelial function that has been widely employed in clinical studies of vascular biology. The technique uses high-definition ultrasound to measure brachial artery diameter before and after an increase in shear stress that is induced by reactive hyperemia. The arterial dilatation, quantified as the percent change in arterial diameter, reflects local endothelial release of nitric oxide (NO). This endothelial-dependent response to increased shear stress can be contrasted to the endothelium-independent dilatation observed with nitroglycerin. As an index of endothelial function, FMD can be viewed as a "barometer" of vascular health and is considered a reasonable surrogate marker for assessing atherosclerosis.

Endothelial dysfunction plays a significant role in the atherosclerotic process. Impaired function of the vascular endothelium is associated with a number of vascular changes, such as decreased vasodilatation, development of prothrombotic and proinflammatory states, and smooth muscle cell proliferation, all of which contribute to the formation and progression of chronic atherosclerotic lesions. An increased incidence of adverse cardiovascular events has been reported in subjects with impaired endothelial function compared with subjects with preserved endothelial function. Therefore, endothelial dysfunction as a reaction to increased ambient PM might provide further mechanistic insight into the observed associations between PM exposure and increased morbidity and mortality. Several previous studies have suggested that exposure to air pollutants results in endothelial dysfunction in healthy volunteers.

Now a new study has been conducted to examine the effects of fluctuations in ambient PM exposure, measured at a local air monitoring station, on changes in endothelial function parameters among adults with type 2 diabetes. It was hypothesized that exposure to increased ambient air pollutants results in further impairment of endothelial function. Moreover, effect modification was analyzed by clinical characteristics associated with insulin resistance such as body mass index (BMI), glycosylated hemoglobin A1c (HbA1c), and adiponectin and by daily myeloperoxidase (MPO) level. MPO is an enzyme that binds to the vessel wall, critically modulates structural and humoral integrity of the vessel wall, and depletes vascular NO bioavailability.

To identify susceptible subgroups, effect modification by genes of the antioxidant defense family and the hemochromatosis gene *(HFE)* were analyzed. The protein product of the *HFE* gene modulates iron binding and storage from pulmonary sources. The analyzed polymorphisms are associated with increased iron uptake and may modify the toxic effect of metal-rich PM on the cardiovascular system because iron stores are inversely associated with the gastrointestinal absorption of potentially toxic metals.

In the present study, 22 subjects with type 2 diabetes mellitus in Chapel Hill, North Carolina (USA) were monitored from November 2004 to December 2005. Daily measurements of $PM_{2.5}$ and meteorologic data were taken at central monitoring sites. On 4 consecutive days, endothelial function was measured by brachial ultrasound in all participants and by pulsewave measurements in a subgroup.

Data were analyzed using additive mixed models with a random participant effect and adjusted for season, day of the week, and meteorology.

FMD decreased in association with $PM_{2.5}$ during the first 24 hr, whereas small-artery elasticity index decreased with a delay of 1 and 3 days. These $PM_{2.5}$-associated decrements in endothelial function were greater among participants with a high BMI, high HbA1c, low adiponectin, or the null polymorphism of glutathione S-transferase M1. However, high levels of MPO on the examination day led to strongest effects on endothelial dysfunction.

The study showed an immediate association between altered endothelial function and PM in persons with type 2 diabetes. Markers for insulin resistance (BMI, HbA1c, adiponectin) were associated with enhanced effects of PM on endothelial function. Individuals with greater oxidative potential were more susceptible to PM exposure. These data suggest that the adverse cardiovascular consequences of air pollution in patients with diabetes may be mediated, at least in part, by impaired function of the vascular endothelium, and that people with diabetes are an especially sensitive subpopulation that needs to be protected from the harmful effects of air pollution. The role of airborne PM in the pathophysiology of insulin resistance, diabetes, and their complications requires further study but does suggest opportunities to promote better health.

Source: Environmental Health Perspectives, Vol. 116, No. 12, December 2008.

PHYTOREMEDIATION AS AN ALTERNATIVE TO EXCAVATION TO REMEDIATE CONTAMINATION IN SOIL

Exposure to soil contaminated with heavy metals may deleteriously affect human health. Deleterious effects may occur from inhalation, ingestion, or absorption of these toxins. The presence of heavy metals in soil may be naturally occurring or due to anthropogenic activities, such as manufacturing or agricultural practices. For example, lead arsenate was a commonly used pesticide until the development of organic pesticides in the middle of the twentieth century.

The conventional remediation strategy for contaminated soil involves excavation followed by transport to storage location. Although widely used because of its effectiveness, excavation is an extremely costly and disruptive process. An alternative to these traditional practices is phytoremediation, which employs the use of plants to remediate contaminated soil. Its principal advantage is its lower cost compared to conventional treatments. Plants most suitable for phytoremediation are able to hyperaccumulate contaminants, possess tolerance to these chemicals, have a high biomass, and have a short growing cycle.

In a recent study two sets of experiments were conducted. First, the use of *Allium fistulosum* (green onions) for phytoremediation of lead was investigated. Lead-spiked potting soils were prepared to compare the efficiency of extraction of these species. Chelating reagents were investigated to enhance the uptake of lead.

The second study involved determination of the uptake of arsenic species by *Pteris cretica cv Mayii* (moonlight ferns). A hydroponic system was employed to eliminate interactions of arsenic with soil. The relative uptake of arsenic (III), arsenic (V), and monomethylarsenate in ferns was investigated.

In order to evaluate accuracy, lead and arsenic were determined in the standard reference material San Jaoquin soil by inductively coupled plasma optical emission spectrometry (ICP-OES). The analyses were performed five times and the determined concentration of each element shows good agreement compared to the certified concentration.

Green onions were investigated for their potential for phytoremediation of lead and arsenic. None of the plant tissues extracted lead at concentrations greater than 35 mg/kg from the potting soil. These results are consistent with previous research that showed lead has low bioavailability in the absence of chelating reagents. Ethylenediaminetetraacetic acid (EDTA) and propylenediaminetetraacetic acid (PDTA) were applied to lead-spiked potting soils in which green onions were grown to evaluate their effectiveness at increasing lead bioavailability. Lead was poorly extracted by green onions (less than 25 mg/kg) without chelating reagents. EDTA significantly enhances lead accumulation in stems, with a lead concentration close to 225 mg/kg. EDTA had little effect on lead uptake in roots and leaves. The addition of PDTA did not significantly enhance phytoextraction compared to experiments without chelating agents. As anticipated from previous studies involving other plants, EDTA was more effective for phytoremediation than PDTA.

Moonlight ferns were grown hydroponically with hydroponic solution and were exposed to one of six arsenic treatments: Control-no arsenic; arsenic (III); arsenic (V); monomethylarsenate (MMA); arsenic (III) and MMA; and arsenic (III) and arsenic (V). Elemental analysis of arsenic from the dried powdered ferns was performed by ICP-OES.

Moonlight fern fronds accumulated arsenic (III) preferentially to arsenic (V) which was preferential to MMA. The combination of arsenic (III) and arsenic (V) showed significant accumulation in the fronds of moonlight fern compared to plants exposed to both arsenic (III) and MMA. It is particularly interesting that the lowest accumulation was observed with the accumulation of arsenic (III) and MMA. These data suggest that inorganic arsenic is accumulated preferentially to MMA.

The study showed green onions *(A. fistulosum)* to be a potential candidate for the phytoremediation of lead. EDTA was shown to be superior chelating for lead than PDTA for green onion phytoremediation. Moonlight ferns *(P. cretica cv Mayii)* were grown under hydroponic conditions that were exposed to different arsenic species, including controls, arsenic (III), arsenic (V), MMA, arsenic (III) and MMA, and arsenic (III) and arsenic (V). Arsenic accumulation was highest in the foliage of moonlight ferns exposed to arsenic (III). The low uptake of MMA alone and with arsenic (III) suggests that organic arsenic does not accumulate as effectively as inorganic arsenic.

Source: Microchemical Journal, Vol. 91, Issue 1, January 2009.

THE EFFECT OF CADMIUM EXPOSURE ON BLOOD PRESSURE

(Continued from page 3)

differential nature of the measurement errors arising from this proxy doses, the risk should have been underestimated in this multiple regression analysis.

Other limitations of this study include rather limited statistical analyses. Path analysis may have contributed to sorting out the relationships among cadmium exposure, kidney toxicity, and blood pressure, but as the data collection was cross-sectional, more definitive answers cannot be obtained until further prospective study is performed.

However the study concluded that at the current level of cadmium exposure (mean blood cadmium 1.67 µg/L), cadmium may have increased the blood pressure and the risk of hypertension in the general adult Korean population. Modification of cadmium effect on hypertension by kidney function is evident in this population-based study, and these findings imply that the nephrotoxicity of cadmium could be an important mechanism by which blood pressure and hypertension are induced.

Source: Science of the Total Environment, Vol. 407, Issue 1, December 2008.

Effects of Metal Exposures at Environmental Levels on Human Semen Quality

The general population is exposed to metals at low concentrations either voluntarily through supplementation or involuntarily through intake of contaminated food and water or contact with contaminated soil, dust, or air. Some metals, such as cadmium (Cd), lead (Pb), arsenic (As), and mercury (Hg), are nonessential xenobiotics that can be measured in most of the general population. Because widespread human exposure and body burden have been demonstrated, there is growing concern for adverse health effects associated with low-level exposures encountered in the environment. Human and animal evidence suggests that these metals may have adverse impacts on male reproductive health at relatively low levels. For example, Cd has been linked to poor human semen quality and DNA damage; Pb may adversely affect sperm shape, motility, and DNA integrity; and methylmercury is associated with sperm abnormalities in subfertile males. However, human data on nonoccupational exposure to these metals has been limited, lacking, or inconsistent across studies.

Now a new study has been designed to explore relationships between these nonessential metals and semen quality among men with exposure levels that are representative of those found among the U.S. general population.

Several other metals, such as chromium (Cr), copper (Cu), manganese (Mn), molybdenum (Mo), selenium (Se), and zinc (Zn), are essential for good health but may be harmful above certain levels. For example, Cr, Mn, and Cu, which act as cofactors for a variety of important enzymes, have been associated with reduced semen quality in rodents and in humans. Mo is also an important cofactor for a limited number of human enzymes and has demonstrated reproductive toxicity in animal studies. On the other hand, low doses of metals such as Cu, Se, and Zn may have protective effects on male reproductive outcomes and may assist in counteracting the effects of Cd, Pb, or other metals.

Because the potential exists for a number of metals to positively or negatively affect male reproduction either individually or together, these metals were included in the analysis carried out in the present study.

Among a number of notable findings involving the relationship between several metals and semen quality, the associations involving Mo appeared to be the most consistent across the different statistical approaches used.

The study found significant or suggestive associations and dose-dependent trends between Mo in blood and declined sperm concentration and morphology, even when considering numerous covariates and blood concentrations of other metals.

Mo is a ubiquitous trace element found in food and drinking water and is present in multivitamin/multimineral supplements. Among foods, Mo is found at higher concentrations in leafy vegetables and legumes. Mo concentrations in food, especially plants, depend greatly on species and soil characteristics. Concentrations of Mo in drinking water also likely vary. It was present at detectable levels in most (62%) groundwater or surface water samples tested in the United States over the last 15 years, collected mostly during land use surveys, with concentrations ranging from <0.05 µg/L to more than 4,500 µg/L. Human exposure may be elevated in areas involved in the mining of Mo ore, or can also result from certain industrial operations. Mo is used in the manufacture of electronic parts, glass, ceramics, and lubricants; in the production of catalysts and pigments; in steel alloys; and in chemical reagents found in hospital laboratories.

A limitation of the present study was the high percentage of blood samples with Mo concentrations less than the limit of detection (LOD), which hindered further investigation of dose-response relationships and metal-metal interactions. Mo is quickly excreted in urine and has been found in higher concentrations in the kidneys of animals and humans compared with other organs. Thus, more sensitive biomarkers and assays, such as the measurement of Mo in urine, which has been able to quantify exposure in a high percentage of samples from the U.S. general population, should be implemented in future studies of Mo exposure and adverse male reproductive outcomes.

Source: Environmental Health Perspectives, Vol. 116, No. 11, November 2008.

INTER-UNIVERSITY POST-GRADUATE EDUCATION PROGRAM IN ENVIRONMENTAL TOXICOLOGY, TECHNOLOGY AND MANAGEMENT

(Continued from page 1)

created by CRI through the support of United Nation Development Programme (UNDP). The curriculum development committee consisted of a team of local experts from CRI, MU, AIT, and a team of international experts from North America, Europe, and the United Nations.

The design of the program is based on the recognition that in developing countries there is a severe shortage of trained and qualified personnel in both government and industry needed for policy/decision making, research/development, and management of toxic chemicals to cope with rapid industrialization. It is also evident that effective management of toxic chemicals in developing countries requires technical and management personnel with broader background knowledge in both health science and environmental management.

This innovative, multidisciplinary program is a combination of health sciences, biotechnology, and environmental engineering designed to train human resources capable of undertaking control and management of toxic chemicals as well as research and development in the areas of toxicology, technology (including biotechnology), and environmental management.

Special Features – The special features of the program are:

- It is an international program with world renowned international experts in the teaching faculty.
- Some courses are operated as a joint-effort between the program and leading foreign institutions such as Massachusetts Institute of Technology.
- Linkages have been established with various institutions in Europe and North America to conduct collaborative research and to supervise student dissertation research.
- Opportunities exist for Doctoral degree students to receive research training at world renowned institutes in USA, Europe, and Asia. Graduates of this professional degree program will have the opportunity to familiarize themselves with global and international issues associated with chemicals and hazardous wastes and the current strategies to manage and solve problems through teaching by international experts from North America, European Union, Asian and international organizations who join the program as **visiting professors**.
- In 2003, the program established a cooperation agreement with University of Utrecht in the Netherlands to offer the possibility for students from both sides to participate in our respective Doctoral degree programs according to the specific requirements set for each program, and to take another degree.

Master's Degree Program: August each year is the normal time of admission and entry annually to the four-semester (22 months) Master's degree program. Students have to complete a program of coursework of a minimum of 26 credits, and a research thesis (22 credits).

Doctoral Degree Program: Doctoral degree students, after receiving their Master's degree from the same program, are given flexible entry timing and are required to complete a minimum of 18 credits of coursework, of which not more than 6 credits are earned from special studies. Students must have taken their Advancement to Candidacy not later than the end of their third semester of study, and completed all the requirements for the Doctoral degree within five years of Advancement.

Admission Requirements:

To be eligible for admission to the Master's degree program a candidate must hold a Bachelor's degree (normally from a four-year program) or its equivalent preferably in Biological Sciences, Chemistry, Engineering, Natural Sciences, Medical Sciences, Agriculture or in a related field. Candidates to the Doctoral degree program should hold a Master's degree or its equivalent from an institution of good standing and should normally have a GPA of 3.50 at the Master's level.

Since the post-graduate program was first launched, there have been 48 Master's degree students and 44 Doctoral degree students. A total of 66 students have graduated, 40 at Master's level (from Bangladesh, Finland, Indonesia, Mongolia, Myanmar, Nepal, Philippines, Sri Lanka and Thailand) and 26 at Doctoral level (from China and Thailand).

For more information, please visit the website:

http://www.cri.or.th/en/envtox/et_postgrad.htm

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