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OVERVIEW OF THE IMPACT OF AIR AND WATER POLLUTION ON FLORA AND FAUNA

CHINA SKILLSHARE ON CHEMICAL SAFETY
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Abstract

Serious contamination of the environment is a global issue. It has been brought about primarily by unsustainable consumption in developed countries and the desire of developing countries to feed that consumption. While in some regions of the world due to poverty or the need to develop, little thought is given to the impact of chemicals on the environment. In other countries, many of the planning decisions are based on the 'critical load' mentality that is, we can pollute up to the amount that an ecosystem can tolerate and above which, the environment and its flora and fauna are overtly harmed.

However, a growing body of research has shown that even low levels of exposure to chemical contamination have chronic and subclinical effects on the environment and our vulnerable wildlife. The ever-growing mixtures of man made chemicals (eg POPs, surfactants, pesticides) poison the immune systems of our fauna, cause cancerous growths and birth defects, are neurotoxic and disrupt endocrine and reproductive systems. Any of these factors can lead to the inability to function normally, breed successfully or obtain food and as a result, reduce species viability.

Besides the adverse effects on wildlife, chemical pollutants also pose public health concerns due to the contamination of the human food chain and in particular, the native foods of indigenous peoples. This is clearly evident in both the global contamination of seafood with mercury and in the Stinky Whale Syndrome of the northern Gray Whales, which has left their meat odorous and unpalatable.

1.0 Priority Environmental Pollutants

Many chemicals in use today are transboundary, respecting no national borders and contaminating countries, regions and the global commons. Chemicals such as persistent organic pollutants (POPs) and other persistent bioaccumulative toxins are often referred to as *'poisons without passports'* as they are volatile and are capable of traveling vast distances on air and water currents.

Atmospheric contamination is thought to be one of the most important stressors on biota (second only to land use changes). This is because the atmosphere affects all exposed surfaces all the time and no other medium can transport huge amounts of pollutant over such large distances in so short a time.

Some of the most notable pollutants include the *'criteria air pollutants'* like sulphur dioxide (SO2), nitrogen oxides (NOx) and carbon monoxide (CO) as well as ozone, volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Other priority pollutants include POPs like dioxins and polychlorinated biphenyls (PCBs), pesticides, perfluorochemicals, brominated flame retardants, phthalates, heavy metals (eg mercury and cadmium), and particulate matter (PM).

In many regions of the world, water bodies are now heavily polluted with domestic sewage, industrial effluents, agricultural chemicals and solid wastes. Industrial discharges to water include many chemical pollutants such as petroleum, cyanide, arsenic, solvents and heavy metals, particularly cadmium, zinc, and some organic-metallic compounds. However, a review of pollutant inventories reveals that the bulk of the chemical contaminants released by industry to air are a mixture of PAHs and VOCs.

1.1. Particulate Matter

Particulate air pollution is a very important vehicle for environmental contamination. Particulate matter (PM) is a term used for a type of air pollution that consists of complex and varying mixtures of particles suspended in the air. It is a combination of dirt, dust, pollens, molds, ashes and soot. Particulate pollution comes from factories, vehicle exhaust, wood burning and incineration, mining, construction activity and agriculture.

PM not only causes primary physical tissue damage in mammals through inhalation, which can result in respiratory and cardiac problems and premature death, it also provides an effective way to deliver toxins direct to the lungs of living organisms. Of particular concern are fine particles, that is, those less than 2.5 microns in diameter. A recent study of dioxins and furans in the ambient air of Shanghai demonstrated that almost all the PCDD/Fs and PBDD/Fs emissions partitioned quickly into the particulate phase.[1]

The level of particulates is measured in micrograms per cubic metre of air. The

[1] Huiru Li, Jialiang Feng, Guoying Sheng, Senlin Lü, Jiamo Fu, Ping'an Peng and Ren Man, (2007) The PCDD/F and PBDD/F pollution in the ambient atmosphere of Shanghai, China, *Chemosphere*, In Press, 27 August

European Union stipulates that any reading above 40 micrograms is unsafe. In 2006, it was reported that Beijing's average PM 10 level was 141, according to the Chinese National Bureau of Statistics,[2] however researchers have noted recent improvements in air quality. [3]

Particulates are easily deposited into water bodies, adding to the existing contamination of streams, rivers and oceans. Particulate air pollution can also significantly increase the size of hail, and thus the amount of damage it can cause to crops and the environment.[4]

1.2 Acid Rain

Acid rain is the result of serious air pollution. It is caused by the transformation of sulphur dioxide (SO_2) and nitrogen oxides into secondary pollutants such as sulphuric acid (H_2SO_4), ammonium nitrate (NH_4NO_3) and nitric acid (HNO_3). The transformation occurs as the pollutants are transported in the atmosphere over vast distances. The production of acid rain is reported to affect 30% of China's total area mainly due to coal fired power stations and vehicle pollution. [5]

The resultant acidification causes the leeching of nutrients from soils and can inhibit germination and reproduction. Acid rain and fog damages the surfaces of leaves, reducing a tree’s ability to withstand cold and disease, leading to loss of habitat and food sources with many flow-on effects throughout ecosystems. Acidification also affects wildlife and native foods in a range of diverse ways. In fish, it corrodes gill material, and attacks the calcium content of the skeleton. It can cause the failure of female fish to spawn, with hatchlings or small fry unable to withstand acidity. If they survive there can be decreased growth rates, inability to self-regulate body chemistry, reduced egg deposition, deformities, increased susceptibility to disease. Acid rain was linked to the decline in Atlantic Salmon stocks by 75% between 1975 and 2000.[6] The reduced fish stocks in turn causes a loss of the calcium-rich food sources required by some bird species.

2.0 Role of Agriculture in Air and Water Pollution

Many agricultural pesticides are detected in ambient air and water. For example, in Australia, the organophosphate, chlorpyrifos was identified as one of the most

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[2] China Environmental News Digest: August 2007, ‘Chocking on Growth’ Daily updated Environmental news related to China Wednesday, August 29, 2007

[3] Honghong Yia, Jiming Haoa, & Xiaolong Tang (2007) Atmospheric environmental protection in China: Current status, developmental trend and research emphasis, *Energy Policy*, Volume 35, Issue 2, 907-915

[4] ‘Air pollution causes bigger, more destructive hail’, CLIMATE SCIENCE (AFP) Sept 12, 2007 Agence France Presse www.terradaily.com/reports/Air_pollution_causes_bigger_more_destructive_hail_999.html

[5] Honghong Yia, et al (2007)

[6] Lisa Phinney Air Quality Sciences, Meteorological Service of Canada, Environment Canada, ‘Environmental Impacts of Air Pollution,’ Presentation to 2004 Canadian Acid Deposition Science Assessment

commonly detected pesticide in urban air.[7] Whereas, organochlorine insecticides, such as endosulfan and its metabolites have regularly been detected in rain and snow samples, as well as groundwater, surface water and sediment.[8] Endosulfan's ability to volatilise has also seen it transported over long distances in air.[9] Endosulfan and its metabolites can affect the permeability of root membranes, inhibiting and stunting new growth and is toxic to a wide variety of microorganisms. Non organic agriculture is also major source of chemical pollutants such as nitrates and phosphates which change the chemical makeup of waterways and can lead to algae blooms and eutrophication.

3.0 Contamination with Domestic and Industrial Products

Many chemicals found in domestic products add to air and water pollution. For example, chemicals like perfluorooctanoate acid (PFOA) used to manufacture water and stain resistance compounds has been detected in surface water, [10] oceans,[11] ambient air [12] and household dust.[13]

Perfluorocarboxylic acids (PFCAs) are extremely persistent and via their precursors, have a real potential for long-range atmospheric transport (based on their vapour pressure and the estimated atmospheric lifetime). PFCA precursors are used in the manufacture of fluoropolymers and fluorotelomers, which in turn are used in a wide range of consumer and industrial products, including non stick and stain resistant coatings, fast food packaging, personal care and cleaning products and telecommunications and computer chip processing equipment.

Their breakdown products are released at various stages in the lifecycle of their production and product life span. Atmospheric degradation of the fluorotelomer alcohols, the volatile precursors to the PFCAs explain the presence of long-chain PFCAs including PFOA in Arctic animals far from the original source. The degree of conversion of fluorotelomer alcohols to PFCAs appears dependent upon NOx levels.

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[7] Beard J; Westley-Wise V; Sullivan G , (1995) "Exposure to pesticides in ambient air.", *Aust Journal of Public Health* Aug;19(4) pp 357- 362

[8] ENDOSULFAN, Draft Dossier prepared in support of a proposal of endosulfan to be considered as a candidate for inclusion in the UN-ECE LRTAP protocol on persistent organic pollutants, German Federal Environment Agency – Umweltbundesamt, BerlinSeptember 2004; Also see Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Ed. P.H.Howard Lewis Pub. Michigan 1991

[9] See Rome F.Quijano, MD, (2000) "Risk Assessment in a Third World Reality , An Endosulfan Case History, *Int. J. Occup. Environmental Health*, Vol6/No 4, Oct/Dec 314-5; Also see Brief Overview Of Endosulfan Review, National Registration Authority Existing Chemical Review Program's Review of Endosulfan, August 1998

[10] Bryan Boulanger, John Vargo, Jerald L. Schnoor, and Keri C. Hornbuckle, (2004) Detection of Perfluorooctane Surfactants in Great Lakes Water. *Environ. Sci. Technol.,* 38 (15),4064-4070,

[11] Yamashita N, Kannan K, Taniyasu S, Horii Y, Petrick G, Gamo T., (2005) A global survey of perfluorinated acids in oceans. (National Institute of Advanced Industrial Science and Technology, Japan) *Mar Pollut Bull*. May 20; [Epub ahead of print]

[12] Barber, J, Berger, U, Jones, K, A study of fluorinated alkyl compounds in European air samples. SEATAC 2005. Available at http://abstracts.co.allenpress.com/pweb/setac2005

[13] Kubwabo C, Stewart B, Zhu J, Marro L., (2005) Occurrence of perfluorosulfonates and other perfluorochemicals in dust from selected homes in the city of Ottawa, Canada. *J Environ Monit*. 7(11):1074-1078.

Studies focusing on PFOA demonstrate that there are no ready environmental degradation mechanisms (eg hydrolysis, photolysis, or biodegradation) for these compounds.

The detection of these and other chemicals such as some brominated flame retardants used in computers and whitegoods[14] and the phthalates in the dust of homes clearly demonstrates that gassing off from domestic products such as treated furnishings, carpets and computers is a significant source of environmental pollution.

There are also major threats to water quality from inadequate treatment of both municipal and industrial wastewater. Many contaminants are not captured or destroyed in waste water treatment plants and are found in the sludge and effluent. For example, polybrominated diphenyl ethers (PBDEs) (a type of brominated flame retardant) have been regularly detected in sewerage sludge and effluent at very high levels.[15] Perfluorochemicals are also regular contaminants of sewerage sludge and effluent,[16] representing a significant risk to the environment and agriculture when it is applied to land or released into waterways. [17]

4.0 Impacts of Air and Water Pollutants on Wildlife

Pollution affects all species. Across the globe, animals, like humans are contaminated with pesticides, industrial chemicals and compounds found in our everyday products. The impacts of this contamination are extensive and varied. While acute toxicity and poisonings may result in death, chronic effects may have a greater impact on populations than acute mortality (for example, eggshell thinning in birds of prey due to DDT residues). Chronic low-level exposure to chemicals, their metabolites and mixtures can result in a range of impacts including immunotoxicity, carcinogenicity, teratogenicity and behavioural disturbances such as lengthened courtship and/or delayed nesting. Recent research has shown that chronic exposure to some chemicals (eg, endosulfan, phenol, chlorpyrifos) can reduce a species tolerance of increased temperatures,[18] which is of concern in a world affected by climate change ad global warming. Recently, a decline in vulture population in the Indian subcontinent has

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[14] Gevao B, Al-Bahloul M, Al-Ghadban AN, Al-Omair A, Ali L, Zafar J, Helaleh M. (2006) House dust as a source of human exposure to polybrominated diphenyl ethers in Kuwait. *Chemosphere*, January 4

[15] Moche W, Thanner G. Federal Environment Agency of Austria, Vienna, Austria. Levels of PBDE in effluents and sludge from sewage treatment plants in Austria. Brominated Diphenyl Ether (BDE) Residues in Canadian Human Fetal Liver and Placenta. Third International Workshop on Brominated Flame Retardants, University of Toronto, Ontario, Canada, June 6-9, 2004; Also see Hale RC, Alaee M, Manchester-Neesvig JB, Stapleton HM, Ikonomou MG (2003) Polybrominated diphenyl ether flame retardants in the North American environment. *Environ Int* 29:771-779

[16] Higgins CP, Field JA, Criddle CS, & Luthy RG., (2005) Quantitative determination of perfluorochemicals in sediments and domestic sludge. *Environ Sci Technol*. June 1;39(11):3946-56

[17] Kröfges P, Skutlarek D, Färber H, Baitinger C, Gödeke I, Weber R, 'PFOS/PFOA Contaminated Megasites In Germany Polluting The Drinking Water Supply Of Millions Of People,' Presentation DIOXIN 2007 International Symposium

[18] Ronald W. Patra, John C. Chapman, Richard P. Lim, And Peter C. Gehrke (2007) The Effects of Three Organic Chemicals on the Upper Thermal Tolerances of Four Freshwater Fishes, *Environmental Toxicology and Chemistry*, Vol. 26, No. 7, pp. 1454–1459

been linked to drug residues.[19]

Most importantly, many persistent synthetic chemicals (eg atrazine, bisphenol A, phthalates) have serious sub-lethal endocrine impacts, which can result in decreased fertility, thyroid dysfunction, and feminization and demasculinization in males.

4.1 Persistent Organic Pollutants (POPs)

One of the most studied group of environmental contaminants are the twelve POPs (eg dioxins, PCBs, HCB and the organochlorine pesticides.) POPs are lipophilic, and thus accumulate in the fatty tissue. In marine mammals, for example, PCB levels can be ten times higher in blubber than in the muscle or other tissues.

Due to a process known as biomagnification, animals high on the food chain, such as bears, dolphins, whales and seals (and humans), can be exposed to very high concentrations of POPs and other persistent bioaccumulative toxins. These chemicals move up through the food chain, increasing their concentrations each time that contaminated prey is eaten. Once the contamination reaches the top of the food chain, the level of toxins can be many times greater than in the surrounding environment.

Contamination with POPs has been linked with many adverse impacts on wildlife. In the 2003 report [20] of affected wildlife in Arctic environments, a number of field studies on polar bears, seals and glaucous gull looked for correlations between effect parameters and individual concentrations of POPs. These studies showed correlations between high PCB levels and reduced vitamin A and/or thyroid hormones in Alaskan northern fur seals and Svalbard polar bears, and reduced testosterone levels in Svalbard polar bears. Similar correlations were seen between high PCB levels and increased cytocrome P450 activity in Arctic birds, ringed seals and polar bears. In harp seals there were correlations between high toxaphene levels and increased cytochrome P450. Correlations between high PCB burdens and adverse impacts on reproduction and adult survival in glaucous gull were evident as were correlations between high PCB, DDT and mirex, and immune status.

In experiments with polar bears, high PCB levels were correlated with reduced antibody production, reduced lymphocyte response and decreased IgG levels. Similar results were obtained in a study on Alaskan northern fur seal. In experimental studies with glaucous gull correlations were found between high POP levels in the diet and increased frequency of chromosome abbreviations and DNA adducts.

4.2 Other Persistent Bioaccumulative Toxins

There are many other persistent bioaccumulative toxins (PBTs) that represent significant risks to wildlife, including the brominated flame retardants (PBDEs) and

[19] Swarup, D., Patra, R. C., Environmental pollution and its impact on domestic animals and wildlife Indian *Journal of Animal Sciences*, 2005 (Vol. 75) (No. 2) 231-240)
[20] Geir W. Gabrielsen, Even H. Jørgensen, Anita Evenset and Roland Kallenborn, Report from the AMAP Conference and Workshop Impacts of POPs and Mercury on Arctic Environments and Humans, Tromsø, 20-24 January 2003

perfluorochemicals such as perfluorooctanesulfonate (PFOS) and perfluorocarboxylic acids (PFCAs). These contaminants have also demonstrated bioaccumulation and biomagnification in recent studies.[21] PFOS, which is currently being assessed as a new POPs, has regularly been detected in the wildlife of Alaska and the Arctic Circle, [22] particularly, in high order species such as polar bears [23] and marine mammals such as seals.[24] PFCAs are also widespread in Arctic wildlife, accumulating in the blood, liver and kidneys of wildlife such as dolphins and polar bears,[25] birds [26], fish,[27] and other marine wildlife [28] including turtles.[29] Long-chain PFCAs have been found to biomagnify in the bottlenose dolphin food web. There is also evidence that for some PFCAs (C9 and C10), the concentrations found in the highly vulnerable polar bears have been doubling every 5 to 8 years. [30]

While perfluorooctanoate (PFOA) has shown to be tumourigenic and immunotoxic in laboratory animals, for other PFCAs, there is no toxicological or ecotox data

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[21] Rossana Bossia, Frank F. Riget, Rune Dietz, Christian Sonne, Patrik Fauser, Maria Dam and Katrin Vorkamp., Preliminary screening of perfluorooctane sulfonate (PFOS) and other fluorochemicals in fish, birds and marine mammals from Greenland and the Faroe Islands. *Environmental Pollution Volume* 136, Issue 2 , July 2005, 323-329; Gregg T. Tomy, Wes Budakowski, Thor Halldorson, Paul A. Helm, Gary A. Stern, Ken Friesen, Karen Pepper, Sheryl A. Tittlemier and Aaron T. Fisk, Fluorinated Organic Compounds in an Eastern Arctic Marine Food Web, *Environ. Sci. Technol*., 38 (24),6475 -6481, 2004.

[22] Kurunthachalam Kannan, Se Hun Yun and Thomas J. Evans, Chlorinated, Brominated, and Perfluorinated Contaminants in Livers of Polar Bears from Alaska. *Environ. Sci. Technol*., 39 (23), 9057 -9063, 2005

[23] Smithwick M, Mabury SA, Solomon KR, Sonne C, Martin JW, Born EW, Dietz R, Derocher AE, Letcher RJ, Evans TJ, Gabrielsen GW, Nagy J, Stirling I, Taylor MK, Muir DC. (2005) Circumpolar study of perfluoroalkyl contaminants in polar bears (Ursus maritimus). *Environ Sci Technol*. Aug 1;39 (15):5517-23

[24] Bossi R, Riget FF, Dietz R., Temporal and spatial trends of perfluorinated compounds in ringed seal (Phoca hispida) from Greenland. *Environ Sci Technol*. 2005 Oct 1;39(19):7416-22

[25] Magali Houde, Trevor A.D. Bujas, Jeff Small, Randall S. Wells, Patricia A. Fair, Gregory D. Bossart , Keith R. Solomon, & Derak C.G.Muir, (2006) Biomagnification of Perfluoroalkyl Compounds in the Bottlenose Dolphin (*Tursiops truncatus*) Food Web, *Environmental Science & Technology,* Vol. 40, No. 13, pp4138- 4141; Also see Houde M, Wells RS, Fair PA, Bossart GD, Hohn AA, Rowles TK, Sweeney JC, Solomon KR, Muir DC.,(2005) Polyfluoroalkyl compounds in free-ranging bottlenose dolphins (Tursiops truncatus) from the Gulf of Mexico and the Atlantic Ocean. *Environ Sci Technol*. Sep 1;39(17):6591-8.;

[26] Verreault J, Houde M, Gabrielsen GW, Berger U, Haukas M, Letcher RJ, Muir DC., (2005) Perfluorinated alkyl substances in plasma, liver, brain, and eggs of glaucous gulls (Larus hyperboreus) from the Norwegian arctic. *Environ Sci Technol* Oct 1;39(19):7439-45

[27] Jesus Olivero-Verbel, Lin Tao, Boris Johnson-Restrepo, Jorge Guette-Fernández, Rosa Baldiris-Avila, Indira O'byrne-Hoyos and Kurunthachalam Kannan., Perfluorooctanesulfonate and related fluorochemicals in biological samples from the north coast of Colombia. *Environmental Pollution*, Article in Press.

[28] Gregg T. Tomy, Wes Budakowski, Thor Halldorson, Paul A. Helm, Gary A. Stern, Ken Friesen, Karen Pepper, Sheryl A. Tittlemier and Aaron T. Fisk, (2004) Fluorinated Organic Compounds in an Eastern Arctic Marine Food Web, *Environ. Sci. Technol.,* 38 (24), 6475 - 6481

[29] Jennifer M. Keller, Kurunthachalam Kannan, Sachi Taniyasu, Nobuyoshi Yamashita, Rusty D. Day, Michael D. Arendt, Al L. Segars and John R. Kucklick, (2005) Perfluorinated Compounds in the Plasma of Loggerhead and Kemp's Ridley Sea Turtles from the Southeastern Coast of the United States. *Environ. Sci. Technol.,* 39 (23), 9101 -9108

[30]Action plan on perfluorocarboxylic acids and precursors, Environment Canada and Health Canada, http://www.ec.gc.ca/nopp/DOCS/consult/PFCA/EN/actionPlan.cfm.

available. PFOA causes liver, testicular and pancreatic tumours in rats,[31] and is also a reproductive toxin in rats, causing increased mortality of rat pups. PFOA has been shown to be immunotoxic in mice. Japanese research had shown that PFOA can alter the expression of over 500 genes, [32] while Chinese researchers investigating the genotoxic potential of PFOA in human liver cells (hepatoma HepG2 cells) in culture have demonstrated that PFOA exerts genotoxic effects on these cells, probably through oxidative DNA damage.[33] There is indication that some PFCAs inhibit the activity of the 'efflux transporters' that serve as a first line of cellular defense against xenobiotics in marine mussels. Since these 'efflux transporters' also exist in mammals, the study raises questions about the long-term consequences of exposure to these PFCAs [34].

PBDEs have been detected in seabird eggs including peregrine falcon, golden eagle, osprey, merlin, goshawk, and white-tailed sea eagle from Norway.[35] It is estimated that levels of PBDEs are doubling every 5 years and levels in peregrine falcons are approaching levels that have caused neurological damage in laboratory experiments with rats. The St. Lawrence Estuary beluga whales doubled their blubber concentration of PBDE congeners in less than three years.[36] PBDEs are developmental neurotoxins, blocking the functioning of the thyroid hormone at critical times in development and impacting on behaviour and normal development.[37]

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[31] PRELIMINARY RISK ASSESSMENT OF THE DEVELOPMENTAL TOXICITY ASSOCIATED WITH EXPOSURE TO PERFLUOROOCTANOIC ACID AND ITS SALTS, U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics Risk Assessment Division, April 10, 2003

[32] Guruge KS, Yeung LW, Yamanaka N, Miyazaki S, Lam PK, Giesy JP, Jones PD, Yamashita N., Gene Expression Profiles in Rat Liver Treated With Perfluorooctanoic Acid (PFOA). *Toxicol Sci*. 2005 Oct 12; [Epub ahead of print]

[33] Yao X. & Zhong L., Genotoxic risk and oxidative DNA damage in HepG2 cells exposed to perfluorooctanoic acid. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis* Volume 587, Issues 1-2 , 10 November 2005, Pages 38-44

[34] *Science News* – September 21, 2005, "Fluorinated compounds in the environment: More than PFOA"; The intermediate fluorotelomer carboxylic acids, which partition into water, are four orders of magnitude more toxic to the water flea (Daphnia magna) than PFCAs such as PFOA. While there are no studies on the toxicity of metabolites/precursors in mammals, it was stated the toxicity of the fluorotelomer aldehydes, an intermediate between FTOHs and PFCAs is 10,000 times more toxic to Daphnia magna than the C10 PFCA.

[35] Herzke D, Berger U, Kallenborn R, Nygard T, Vetter W. (2005) Brominated flame retardants and other organobromines in Norwegian predatory bird eggs. *Chemosphere* 61: 441-449. Also see Knudsen LB, Gabrielsen GW, Verreault J, Barrett R, Skare JU, Polder A, Lie E. Temporal trends of brominated flame retardants, cyclododeca-1,5,9-triene, and mercury in eggs of four seabird species from Northern Norway and Svalbard, Norwegian Polar Institute, Tromso University Museum, National Veterinary Institute of Norway, Norwegian School of Veterinary Science. SPFO-Report 942/2005, December 2005

[36] Lebeuf M, Gouteux B, Measures L, Trottier S. (2004) Levels and temporal trends (1988-1999) of polybrominated diphenyl ethers in beluga whales (Delphinapterus leucas) from the St. Lawrence Estuary, Canada. *Environ Sci Technol* 38:2971-2977

[37] For example see Dufault C, Poles G, Driscoll LL. (2005) PBDE exposure alters learning and the cholinergic modulation of attention in rats. *Toxicol Sci* 88:172-180; Viberg H, Frediksson A, Eriksson P. (2004) Investigations of strain and/or gender differences in developmental neurotoxic effects of polybrominated diphenyl ethers in mice. *Toxicol Sci* 31:344-353; Branchi I, Alleva E, Costa LG. (2002) Effects of perinatal exposure to a polybrominated diphenyl ether (PBDE 99) on mouse neurobehavioural development. *Neurotoxicology* 23:375-384.

4.3 Impact on Marine Mammals

Marine mammals such as cetaceans and seals are particularly affected by environmental contamination as they have limited capacity to metabolise organochlorines in comparison to terrestrial mammals. As early as the 1970s, research was showing that the incidence of DDT and PCBs in the bodies of seals was reducing the individual's chance to reproduce. Either the seals failed to conceive or they aborted or resorpted the foetus.[38] Female Baltic Ringed seals when exposed to organochlorine pollution suffered a narrowing or closure of the uterine passage and hormonally induced softening of the bone.[39]

The biotransformation enzymes, which catalyse or accelerate the degradation of toxic compounds in the cetacean's body are constantly activated or 'induced' by the organochlorine contaminants with serious consequences including the increased elimination of natural hormones. A particular enzyme, cytochrome P450 responsible for the metabolism of PCBs once induced, has a broad range of targets and accelerates the metabolism of the cetaceans' natural chemicals resulting in critical disturbances to the balance of hormones.[40] Examples of this were seen in Dall Porpoises from North West Pacific, which demonstrated that as concentrations of PCBs and DDT increased, the level of male hormone testosterone decreased.[41]

Organochlorine contaminants have also been associated with the growing numbers of seals suffering the disease complex called 'primary lesions of the adrenals with secondary reactions'. The disease is linked to immuno-suppression and hormonal imbalances resulting from contamination, particularly PCBs.[42] While organochlorines have long been known to cause immunotoxic effects on laboratory animals,[43] in recent years they have been linked to the occurrence of large-scale die-offs in marine mammals due to disease. Post mortem testing of these mammals has revealed high levels of PCB and PBDE contaminants in their blubber and organ tissues.[44] Researchers have hypothesized that contaminant induced immuno suppression may contribute to disease susceptibility in harbour porpoises.

In Australia, high organochlorine residues were found in the majority of stranded marine mammals from the Victorian coast.[45] The autopsies indicated that a variety of

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[38] Moscrop, A. & Simmonds, M.P.(1995): The Significance of Pollution for Marine Cetaceans, Scientific Committee, International Whaling Commission Review SC/46/0 14.

[39] Reijnders, P. & Donovan, G.P. (April 1995): Report of the Workshop on Chemical Pollution and Cetaceans Scientific Committee, International Whaling Commission.

[40] Pollack, J., (1993): The Toxicity of Chemical Mixtures - An Introduction to Recent Developments in Toxicology, CHAST & PIAC

[41] Moscrop, et al. (1995)

[42] Olsson, M., Karlsson, B., & Ahnland, E. (1994) : Disease and environmental contaminants in seals from the Baltic and the Swedish west coast. *Sci. Total Environ* 154 217-227.

[43] Evironmental Contaminants in Wildlife, Interpreting Tissue Concentrations Ed. Bayer, Heinz &
Redmon-Norwood, SETAC Special Pub Lewis Pub New York 1996

[44] Beineke A, Siebert U, McLachlan M, Bruhn R, Thron K, Failing K, Muller G, (2005) Investigations of the potential influence of environmental contaminants on the thymus and spleen of harbor porpoises (Phoceona phoceona). *Environ Sci Technol* 39:3933-3938

[45] Dr Cor Lenghaus 1991 unpub, One neonatal killer whale had a total of 28.4 mg/kg DDT in its blubber as well as dieldrin, HCB, BHC, Endrin and heptachlor (0.2 -1.2 mg/kg).

serious infectious diseases - including septicaemia, vegetative endocarditis, congestive heart failure, bacterial pneumonia, and generalised fungal infections - caused the deaths of the whales and that the majority were severely immuno-compromised. Researchers also concluded that the toxin found in the whales and dolphins could have contributed significantly to the diseases, which killed the animals.

The effect of this contamination on native foods is clearly evident in the Stinky Whale Syndrome of the northern Gray Whales, which has left their meat odorous and unpalatable, and causes short-term health effects in some people. Reports by the Russian and US government[46] note that most of the compounds detected in stinky whale meat have minimal to no toxicological information making risk assessment impossible.

4.4 Impacts on Other Aquatic Species

The uptake of pollutants in aquatic systems can be very rapid, taking place through gills, skin and ingestion. Amphibians like frogs are at particular risk as the skin of an adult amphibian is a permeable organ used for respiration. Pesticides such as Atrazine have been closely associated with endocrine disruption in frogs at very low levels.[47]

Shellfish such as mussels and oysters are also particularly prone to the impacts of pollution as they are filter feeders and can bioaccumulate metals and POPs. Even in remote areas, there is widespread contamination with the endocrine disruptor, tributyltin (TBT) used to treat the hulls of ships.[48] TBT (tributyltin) causes female whelks to grow male characteristics and thus becomes sterile when this superficial excretory duct finally blocks the release of eggs.[49] A survey of marine gastropods from the South Australian coast revealed 100% demonstrated `imposex' or a masculinisation of the females of the species.[50]

Concerns over contamination of the aquatic environments with endocrine disrupters have increased even further, with the growing number of studies of waterways from USA, South Africa, United Kingdom and European waterways. In research focusing on UK waterways contaminated with sewerage effluent,[51] the findings indicated that oestrogen type substances were exerting powerful endocrine impacts with 25-60% of

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[46] T. Rowles & V. Ilyashenko, Summary Of Findings On The Investigation Of The Stinky Whale Condition In Eastern North Pacific Gray Whales, Submitted by the United States of America and the Russian Federation, (21 May 2007) Agenda Item 4.1.1 IWC/59/CC 15

[47] See Tyrone Hayes, Kelly Haston, Mable Tsui, Anhthu Hoang, Cathryn Haeffele, and Aaron Vonk, (2003) Atrazine-Induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (Rana pipiens): Laboratory and Field Evidence *Environmental Health Perspectives* • Vol 111 : 4

[48] A Department of Environment (1991) State of the Environment Report, Western Australia 1991

[49] Rejinders, Peter J.H.,(1994): Toxicokinetics of chlorobiphenyls and associated physiological responses in marine mammals, with particular reference to their potential for ecotoxicological risk assessment. *Sci. Total Environ* 154 229-236

[50] Edyvane, K. (1995) Issues in the South Australian Marine Environment, State of the Marine Environment Report for Australia. South Australia Research & Development Institute.

[51] " Pollution Causing Sex Change – Oestrogen like substances are causing male fish to produce eggs. " UK Environmental Agency (23.1.1998 BBC London Pub. 07.13)

male fish producing eggs in their testes. US studies reported a high proportion of wild chinook salmon that appear to have been sex-reversed early in development, that is, chromosomal males have female reproductive tracts. [52]

Pesticides like chlorpyrifos, atrazine and endosulfan also represent a high environmental risk to wildlife. [53] They like POPs, are persistent in ecosystems and demonstrate both chronic and acute toxicity. Fish accumulate endosulfan directly from surrounding water, where it can persist for months.[54] Both endosulfan and chlorpyrifos are very toxic to freshwater fish, aquatic invertebrates and estuarine and marine organisms as well as birds, [55] and have been implicated in fish and bird kills.

4.5 Impacts of Pollution on Birds and Mammals

Birds and mammals are not immune to pollution. Chlorpyrifos has been detected in the eggs (0.06-0.36ppm) and liver (0.02ppm) of the endangered seabirds, Little Terns and in Pelican eggs (0.5ppm) from the central coast of New South Wales, Australia.[56] Arctic birds suffer contamination with perfluorochemicals such as PFOS,[57] as well as PBDEs [58] and mercury.[59]

While the use of organochlorine pesticides in Western Europe ended long ago, DDT, and its metabolites along with other contaminants such as dioxins are still detected at worrying levels in vulnerable bird population. [60] For example, analyses of the eggs of the red kite (*Milvus milvus* L.) population (which is in decline) collected from the Spanish Doñana National Park (DNP), between 1999 and 2001 demonstrated that 50% had DDE concentrations above those associated with reproductive impairment in

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52 Nagler JJ, J Bouma, GH Thorgaard, and DD Dauble. 2001. High Incidence of a Male-Specific Genetic Marker in Phenotypic Female Chinook Salmon from the Columbia River. *Environmental Health Perspectives* 109:67-69.

53 Department of Land and Water Conservation's 1998-99 Central and North west Region's Water Quality Program Reports on Pesticides and Nutrients art sites in Macquarie, Namoi, Gwyder, Darling and Border Rivers as reported in the Inland Rivers Network News, August 2000,
Volume 5, Number 2 at 5

54 Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Ed. P.H.Howard Lewis Pub. Michigan 1991

55 US EPA Pesticide Fact Sheet, Chlorpyrifos 1984

56 NSW Department of Agriculture, Pesticide Analysis No. CP90/633-635 , Re: Pelican Eggs, Little Tern - Wallace Lake Colony

57 Verreault J, Houde M, Gabrielsen GW, Berger U, Haukas M, Letcher RJ, Muir DC., Perfluorinated alkyl substances in plasma, liver, brain, and eggs of glaucous gulls (Larus hyperboreus) from the Norwegian arctic. *Environ Sci Technol*. 2005 Oct 1;39(19):7439-45.

58 Herzke D, Berger U, Kallenborn R, Nygard T, Vetter W. Norwegian Institute for Air Research, NO-9296 Tromso and NO-2027 Kjeller, Norway. dorte.herzke@nilu.no Brominated flame retardants and other organobromines in Norwegian predatory bird eggs. *Chemosphere* 61: 441-449. October 2005

59 Knudsen LB, Gabrielsen GW, Verreault J, Barrett R, Skare JU, Polder A, Lie E. Temporal trends of brominated flame retardants, cyclododeca-1,5,9-triene, and mercury in eggs of four seabird species from Northern Norway and Svalbard, Norwegian Polar Institute, Tromso University Museum, National Veterinary, Institute of Norway, Norwegian School of Veterinary Science. SPFO-Report 942/2005, December 2005

60 Gomara et al., (2007) Unexpected high PCB and total DDT levels in the breeding population of red kite (Milvus milvus) from Doñana National Park, south-western Spain. Environment International. Article in Press.

other raptor species. Concentrations of *ortho* PCBs in 50% of the eggs were much higher than levels reported to cause reduced hatching success, embryo mortality, and deformities in birds (> 20g/g ww). Analysis of the total PCDD/Fs (mean TEQs 238 pg/g ww) indicated that some eggs exceeded the NOEL (67%) and LOEL (33%) with researchers expecting the red kite to experience detrimental effects of dioxin-like toxicity. Remarkably, the average *ortho* PCB and DDE concentrations showed an increase of one order of magnitude compared to previous data for the species during the 1980s.

Even the Platypus, an egg laying monotreme from remote areas in Australia have demonstrated widespread contamination.[61] Samples of tail fat detected PCBs (average of 0.5 mg/kg), DDT (0.6 to 0.8 mg/kg) and HCH. The contaminants have been implicated in the failure of the incubation of clutches of eggs. It has been noted that the unusually yolky eggs of the monotremes may predispose them to teratogenesis of pesticides and the immunotoxicity of PCBs may be contributing to their increased susceptibility to infections.

5.0 NGO and Community Responses to Water and Air Pollution - Community Monitoring Initiatives

There are many community based monitoring projects around the world, which allow civil society to monitor air and water pollution and become active in the protection of the natural environment. Community-Based Monitoring (CBM) is a systematic method of participatory action by the community documenting the impact of pesticides and pollution on health and the environment at the community level. There are some excellent campaigns to address air and water pollution in China, particularly the recently launched NGO Web site that aggregates data about polluting factories, China Water Pollution Maps.[62] NGOs throughout the world have developed environmental protection campaigns based on pollution data from Pollution Release and Transfer Registers (PRTRs). The estimates that 20% to 30% of China's water pollution comes from exported manufacturing goods provides the basis of good consumer campaigns targeting overseas companies and environmentally conscious consumers in other countries.

The Bucket Brigade

http://www.bucketbrigade.net

The Bucket Brigade is a simple, but effective tool that dozens of communities are using to find out what chemicals are in the air. Armed with their own data and information about the health effects of chemicals, these communities are winning impressive reductions of pollution, safety improvements and increasing enforcement of environmental laws. The "Bucket Brigade" is named for a easy to use air sampling device housed inside a 5 gallon plastic bucket. The "Bucket" was developed in Northern California in 1995 by an environmental engineering firm in order to simplify and reduce the costs of widely accepted methods used for testing toxic gases

[61] Munday, B.L., Stewart, N.J., & Sodergren, A., 1998. Occurrence of polychlorinated biphenyls and organochlorine pesticides in platypuses (Ornithorhynchus anatinus) in Tasmania. *Aust Vet J.,* Vol 76, No 2

[62] See Worldwatch Institute, available at http://www.worldwatch.org

in the air.

STREAMWATCH
http://www.streamwatch.org
http://www.streamwatch.org.au

Streamwatch is a school and community education and action program that raises awareness of the natural environment through testing water quality in local rivers and streams. The program empowers groups to protect the health of local waterways through their involvement in water quality monitoring. Streamwatch groups (primary school, high school and community) are trained by their 'regional coordinator' to monitor the water quality in a local river/stream using a Streamwatch kit. Two water quality test kits have been developed for different levels of monitoring. Results of water quality monitoring are uploaded onto the Streamwatch website and those outside the norm are investigated and reported upon.

The Health and Environment Alliance Against Toxics (HEAL-Toxics)
http://www.healtoxics.org/cbm.htm

HEAL-Toxics was formed to support and help facilitate effective engagement by public interest nongovernmental organizations (NGOs) in global, regional and national efforts to promote chemical safety. HEAL-Toxics provides community monitoring methodology and support.

IPEP Projects
http://www.ipen.org/ipepweb1

NGOs involved in the International POPs Elimination Project (IPEP) have completed projects to identify specific pollution problems in their country and have undertaken activities to raise both public and government awareness. Others have mapped hotspots and stockpiles and developed strategies to help manage them at a community level. Overall, IPEP projects have enhanced NGOs capacity to be effective stakeholders in national chemical safety issues helping to prevent or remediate pollution.