Journal of
Bioremediation & Biodegradation
ISSN: 2155-6199

Ramakrishnan, J Bioremediat Biodegrad 2016, 7:4
DOI: 10.4172/2155-6199.1000e175

Editorial Open Access

# Continuing and Emerging Concerns about Contaminants

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Many chemical and microbial constituents that are present in soil and water ecosystems are getting recognized as contaminants after the evaluation of their potential threat to the environmental health. These contaminants demand paradigm shifts in the thinking and management of natural and industrial chemicals and wastes. In general, the contaminants can be of different kinds: 'emerging contaminants' are those which appear recently, contaminants of emerging concerns are those which are in the environment but the concerns are raised recently and 'traditional contaminants' are those which are known chemicals but new facts provide new perspectives [1]. The oldest global contaminant is probably lead (Pb) and its production began about 5000 years ago. The mines of that era would have higher levels of Pb in soils and in the air around. Though it was an emerging contaminant at that time, the poor means of measuring the levels of Pb led to creating awareness of its detrimental effect only in the 70s. Arsenic is another contaminant which was even used as pesticides in China around 900 AD [2]. The reports on its bioaccumulation and its transfer in the food chain have led to the ban of many arsenic containing pesticides very late. Lead and arsenic including several other metal contaminants are traditional contaminants with different emerging concerns even now.

Synthetic pesticides are often considered to be less harmful at the time of their releases and widespread uses. Carson created the vital awareness about the 'emergence' of contaminants by the use of synthetic pesticides [3]. Most of these chemicals also get phased out after their extensive use in agriculture and public health. Dichlorodiphenyltrichloroethane (DDT) has been banned in many countries now [4]. Yet, large amounts of DDT are being produced in India. China and the Democratic People's Republic of Korea are other two countries which produce this chemical substantially. Interestingly, the export of DDT allows its continuous use for vector control in many African countries even now. DDT is well known to bioconcentrate and biomagnify with increasing trophic level in the food chains [5]. Chronic health effects of DDT and the occurrence of resistance to it in the malarial vectors necessitate the monitoring and legislation to enforce the regulations and management of its production and uses. Waning popularity of organochlorine pesticides in the 1970s led to the development and use of organophosphate pesticides. But, the misuse of organophosphorus insecticides causes serious human and environmental health issues [6]. Organophosphate pesticides are an important contributor to occupational pesticide poisoning and self-poisoning [7,8]. Every pesticide that is released becomes a new emerging contaminant. The potential emerging contaminants now include pharmaceuticals, personal care products, fragrances, plasticisers, flame retardants, and nanoparticles along with the naturally occurring algal toxins and rare earths.

Sulfamethoxazole (SMX) is used as an antibiotic to treat the upper and lower respiratory tract infections, renal and urinary tract infections, gastrointestinal tract infections and other infections. SMX has been reported to in the environmental waters and its natural attenuation is groundwater is limited due to the absence of photodegradation. SMX even at one microgram per litre delayed the microbial growth, altered the community composition and retarded denitrification [9]. Kinney and his co-workers showed that pharmaceuticals such as erythromycin, carbamazepine, fluoxetine, and diphenhydramine were present in soil irrigated with reclaimed water from a sewage treatment plant [10]. Several pharmaceuticals, hormones, personal care/domestic use products, plasticizers and other micropollutants are found to move to the groundwater near the septic systems [11]. Both the hydrogeologic and demographic factors could influence the concentrations of these pollutants in the groundwater.

Wastewater treatment plants, surface-runoff, and the depositions from the atmosphere are the important sources of contaminants in the urban waterways. Recently, alklyphenolic endocrine disrupting chemicals [4-nonylphenol (NP), 4- nonylphenolpolyethoxylates (NPEO), 4-nonylphenolethoxycarboxylic acid (NPEC), 4-tert-octylphenol (OP), 4-tert-octylphenolpolyethoxylates (OPEO)], a plastic bisphenol A, and an antimicrobial (triclosan) were reported to be found in the Greater Metropolitan Chicago Area Waterways [12]. The endocrine disrupting chemicals can affect the brain and nervous system, and the reproductive system of fish. Vajda and his coworkers found that the complex mixture of endocrine-active contaminants in wastewater led to adverse effects on the local fish, resulting in the domination by females and about 18 to 22 percent of fish exhibiting intersex [13]. High incidence of intersex in the male smallmouth bass in the Potomac River and its tributaries in Virginia and West Virginia was found in the streams draining areas with intensive agricultural production, relative to the non-agricultural and undeveloped areas [14]. Though the pharmaceuticals and their transformation products can be present as low as 100 nanograms or less per litre, they can cause ill effects on aquatic organisms when exposed on a continual basis. When exposed to the WWTP effluent, the male fathead minnows (*Pimephales promelas*) even produced plasma vitellogenin, a protein associated with egg production in females, but not in males under the normal conditions [15].

Biosolids are produced during wastewater treatment and about 50% of biosolids are land applied [16]. They are an important nonpoint source of organic wastewater contaminants. The land application of wastes containing several chemical substances is an important route by which the soil fauna can take up the contaminants. Earthworms ingest soils and hence, any accumulation of contaminants in soils can lead to their uptake by the earthworms. Kinney and his coworkers suggested that earthworms could serve as indicator species for the bioaccumulation of emerging organic contaminants [17]. The chemical substances used in antibacterial soaps, perfumes and detergents such as phenol, tributylphosphate, benzophenone, and trimethoprim were detected in the earthworms collected from a soybean field fertilized with biosolids.

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**Received** June 10, 2016; **Accepted** June 13, 2016; **Published** June 20, 2016

**Citation:** Ramakrishnan B (2016) Continuing and Emerging Concerns about Contaminants. J Bioremediat Biodegrad 7: e175. doi: 10.4172/2155-6199.1000e175

The emerging contaminants include even the naturally occurring chemicals in soils and waters. In water bodies, algal blooms occur due to excessive accumulation of algae. These blooms contain multiple cyanobacterial toxins (cyanotoxins). Cyanotoxins (e.g., anatoxins, cylindrospermopsins, lyngbyatoxins, microcystins, nodularins and saxitoxins) that are present as few micrograms in a liter can cause allergic, damage to the respiratory tissues, liver and kidneys, and affect the nervous system in mammals. Wood and his coworkers observed interspecific differences, due to the feeding habits, in the accumulation of microcystin in fish and shellfish [18]. Most studies have focussed only on microsytins but the presence of several types of cyanotoxins necessitates the need for innovative assessment methods [19,20]. The impact of agriculture use of lands in watersheds increases the production of cyanotoxins in lakes [21].

Naturally occurring and synthetic nanoparticles are enormously diverse. Both the incidental and engineered nanoparticles that are created by the human activities are increasing in the recent times. The Nanotechnology Consumer Products Inventory has more than 1,800 consumer products suggesting the commercial acceptance of nanotechnologies [22,23]. The consumer products using nanotechnologies include personal care products, clothing, cosmetics, sporting goods, filtration, sunscreens, and automobile parts, those used in electronics, food and beverage, appliances, and goods for children. Globally, titanium dioxide, silicon dioxide and zinc oxide are the most produced nanomaterials. Nearly 528 products have nanomaterials, suspended in a variety of fluids such as water, skin lotion, oil, and car lubricants. Silver nanoparticles are present in about 438 products, which are essentially for antimicrobial protection [23].

Contemporary public health and agriculture depend heavily on the synthetic chemical substances including nanoparticles for improving productivity and protecting the plants, animals and humans. Indiscriminate- and continuous use of these chemical substances can lead to the suitable conditions for microorganisms to evolve, develop capabilities to degrade or even resistance to them. Currently, the development of resistance to antimicrobials in microorganisms has become a serious global issue. By 2050, the global economic cost of antimicrobial resistance (AMR) will be up to $100 trillion along with 300 million premature deaths [24]. The AMR has become an imminent risk to many life-threatening as well as common diseases in animals and humans. Even, many insect pests have been conferred with resistance to pesticides due to the AMR of their microbial endosymbionts.

The degradation of soil-applied pesticides or antimicrobials (such as fumigants) has been found to enhance, especially due to rapid microbial transformation, mineralization or degradation. Many of these chemical substances including pharmaceuticals and nanoparticles may have deleterious, non-target effects on microorganisms. Since several microorganisms have acquired the capabilities to degrade or resist the antimicrobials through changes in their genomes, the predictability on the environmental fate of chemical substances has become increasingly challenged now. Since the horizontal gene transfer (HGT) is a predominant means of gene exchange among microorganisms, the spread of AMR among different microbial groups can be rapid and alarming, beyond the geographical and ecological borders. The challenges in the future will continue to be on gaining a better scientific understanding of the environmental consequences of contaminants in soil, air and water and their effects on diverse organisms.

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