Journal of Environmental Science and Engineering, 5 (2011) 992-1002

# Understanding the Safety, Health and Environmental (SHE) Challenges of Xenobiotics and Their Remedial Approaches

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Received: February 10, 2011 / Accepted: April1, 2011 / Published: August 20, 2011.

**Abstract:** With the use of over 100,000 industrially produced chemicals, there have been several concerns on human health and environment. Most of these chemicals are exposed into the natural environment during the life cycles of their production, transportation, storage, consumption, and as by-products and wastes. The rising rates of cancer, obesity, and infertility suggests that there are compounds recently introduced to the environment that have altered the chemistry of the human body, and it is only with the monitoring of xenobiotics such as Bisphenol A (BPA), nonyphenols, estrogen (natural and synthetic) and other endocrine-disrupting compounds (EDCs) that patterns and links could be drawn. This paper investigates the safety, environmental and health (SHE) impacts caused by BPA, nonyphenols and estrogens. Derived from petroleum, bisphenol A is used in manufacturing plastic consumer products, including certain water bottles, in dental sealants for children's teeth, and in resins used to line tin cans. Nonyphenol is one of the by-products of alkylphenolpolyethoxilates which is widely used as nonionic surfactants. Synthetic estrogen used for birth control pills as well as natural estrogen excreted by women through urine enters the domestic wastewater streams. These compounds are considered to be EDCs and have severe SHE concerns. In this paper, the challenges of entry of these compounds (xenobiotics) into nature, health and environmental issues and their remediation have been reviewed in detail.

**Key words:** Industrially produced chemicals, bisphenol A, nonyphenols, endocrine-disrupting compounds (EDCs), remedial measures, xenobiotics.

## 1. Introduction

Humans today are surrounded by the plethora of chemicals on a daily basis, many of these have severe impacts on the human health and the natural environment. To minimize health and the environmental risks from such chemical substances has become an important issue. There are over 100,000 industrially produced chemicals in use daily [1], there has been a great concern on health and environment as they are discharged into the natural environment during the life cycle of their production, transportation, storage, consumption, and as by-products and wastes. These chemicals have also been used in chemical processes, food production and preservation, water and waste treatment processes among others, colorants, pesticides, herbicides and including therapeutic uses. Even though there have been reports on increasing risks ofseveral synthetic chemicals, their production has not declined, meaning that the risks will continue to surge. As a result, the uses of these chemicals create a myriad of exposures for people in a variety of ways.

The chemical revolution has really been a great concern to the society. For example, DDT was the first pesticide and once it was the most important

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chemicals in many sectors. For discovering DDT, the Swiss scientist Paul Hermann Müller was awarded the 1948 Nobel Prize in Physiology and Medicine. After a long time, it was proved that DDT was poisoning both wildlife and the environment and also endangering human health. Even though DDT was banned in 1972, it is believed that it still persists in the environment, creating several health and environmental problems.

Greensfelder [2] reported a recent study conducted by the University of California Berkeley research team suggesting children who have been exposed to DDT while in the womb have a greater chance to experience developmental problems.

Recent concern over polycarbonate baby bottles made from BPA-containing plastic in the mainstream media has many public interest groups questioning the safety of these bottles, as BPA is a known EDC [3]. Government-regulated organizations, such as the American Food and Drug Administration and the European Food Safety Authority, however, claim that there is no basis for a ban on the already-regulated BPA, and that it does not pose a health risk to consumers [4]. The rising rates of cancer, obesity, and infertility seem to suggest that there is something recently introduced to the environment that has altered the chemistry of the human body, and it is only with the monitoring of newer chemicals such as BPA and other EDCs that patterns and links could be drawn.

## 2. Bisphenol A and Its Effects

BPA is a ubiquitous contaminant found in the environment today. Even though BPA was first synthesized in 1891, the first evidence of its estrogenicity was reported experimentally in the 1930's [5, 6]. It was first synthesized from ethanol and acetone. Later on, it was used as a starting material in the development of the plastic polycarbonate. Polycarbonate is a useful plastic with optical clarity, shatter-resistance and heat tolerance that makes it advantageous over other plastics. Epoxy resins were also developed in the 1950s from BPA, and its commercial production was then intensified as more products were in high demand [7]. BPA as plastic monomer and plasticizer is one of the highest volume produced chemicals in the world. A recent study showed that there is wide-spread BPA contamination in industrialized human populations [8]. The report also suggested that BPA has been repeatedly found in the low ng/mL range in the urine of over 90% of individuals tested in several countries and continents, in addition to the blood of pregnant women, fetal blood, umbilical cords, placenta and amniotic fluid.

BPA as plastic monomer and plasticizer is one of the highest volume produced chemicals in the world. It is also chemically known as 2,2-bis(4-hydroxydiphenyl) propane, a compound that is currently used in the manufacturing of polycarbonate plastics, which are hard, durable Nalgene bottles, as an epoxy resin and as an ingredient in the lacquer coating of canned goods. Over 6 billion pounds of BPA are produced per year, and as a consequence, this compound is discharged into terrestrial, aquatic and marine environments [9]. BPA-based polycarbonate is used as a plastic coating for children's teeth to prevent cavities, as a coating in metal cans to prevent the metal from contact with food contents, as the plastic in food containers, refrigerator shelving, baby bottles, water bottles, returnable containers for juice, milk and water, micro-wave ovenware and eating utensils [10]. As more in-depth research is conducted, it is becoming obvious that BPA has estrogen-like effects in wildlife and in controlled laboratory rat studies. It is still unclear whether or not these effects directly translate to humans, however, it would be difficult to completely dismiss the hazards of BPA simply because the human trials have not been conducted yet.

BPA is considered an EDC and there are many EDCs in our modern environment: synthetic materials and cleaners often contain complex chemicals whose effects, if they are known, can mimic the effects of hormones on our endocrine systems. These hormones

are regulated by the endocrine system, and they are extremely important for regulating the function and growth of our cells [11]. Hormones are alike to chemical messengers that, when present or absent, can regulate mood, growth, tissue function and metabolism. It is important that the endocrine system is thus working properly and receiving the correct feedback from the cells and the chemicals present in the bloodstream. Substances can act as EDCs if they confuse the endocrine system by mimicking hormones or blocking receptors. Because the mechanisms involved in this system are so complex, it is often difficult to discern what the exact effect of a substance is. BPA is considered as endocrine receptor agonist, since it binds to the normal estrogen receptors in cells and can cause adverse effects such as breast cancer, endometriosis, birth defects, and infertility [9].

It is important to note, however, that in adults, the adverse effects of an endocrine-disrupting chemical will usually subside if the chemical is removed from the system, however, long-term damage can occur due to organ damage through weight loss or sexual dysfunction. BPA and other EDCs are often considered most dangerous to a developing fetus; it is in these 9 to 20 months that the blueprints for growth and development will be made, and a young baby is especially sensitive to the hormones cueing the functions of its future organs [11].

Kubo et al. [12] reported that at levels beneath the "safe" level recommended by the EPA, BPA exposure in the womb alters sexual differentiation of the brain and behavior in rats. Murray et al. [13] reported that prenatal exposure to BPA causes breast cancer in adult rats. This report showed that BPA altered the growth of mammary tissues in ways that increase the risk of breast cancer and increase the sensitivity of breast tissue to cancer causing agents. Durando et al. [14] reported that prenatal exposure to BPA causes long-lasting changes in female rat breast tissue resulting to be more sensitive to estrogen at puberty and more susceptible to cancer-causing chemicals as adults. A recent report revealed that chronic exposure to BPA induces insulin resistance in adult mice. This work provides the first experimental link between endocrine disruption and diabetes [15]. The doses used for the experiment were 5000 times below the dose identified by the US EPA as the lowest level causing effects. Moreover, it was reported that BPA has been detected in human tissues from Japan, Germany and in 95% of human urine samples in the US [12]. This clearly indicates that the current standards of human exposure level are also questionable.

Sugiura-Ogasawara et al. [16] provided the first indication that BPA is associated with recurrent miscarriage in women. The level of exposure sufficient for affecting in mice was within the range people experience in the general population. Another study suggested that two estrogenic chemicals ethinylestradiol which is the birth control hormone, and the plastic molecule, BPA can cause adverse effects on the development of the prostate in fetal mice, at levels beneath common exposures experienced by the American public [17]. This finding is the indicator of factors responsible for increases in prostate cancer. A similar study revealed that BPA causes an euploidy in mice at low levels of exposure. It is known that aneuploidy in humans causes spontaneous miscarriages and some 10-20% of all birth defects, including down syndrome, this implicates BPA in a broad range of human developmental errors [18]. VomSaal and Hughes [19] reported that current health standards for BPA, a molecule used widely in commerce to which virtually all Americans are exposed, should be strengthened dramatically to protect public health, requiring a new, formal risk assessment by relevant US agencies. Ramos et al. [20] suggested that BPA can cause changes in rat ventral prostate cells that make nascent prostate tumors in humans more potent. Sakaue et al. [21] showed that BPA lowers sperm count in adult rats even at extremely low levels.

Mittelstaedt et al. [22] reported that BPAis ingested

by practically everyone in Canada who eats canned foods or drinks from a can or hard plastic water bottles. The report further mentioned that scientists consider BPA as an "inherently toxic" chemical and suspect its fingerprints all over the unexplained human health trends emerging in recent decade shinting at something going haywire with sex hormones, including the early onset of puberty, declining sperm counts, and the huge increase in breast and prostate cancer, among other ailments. A joint study conducted by FAO/WHO [23] expert meeting to review toxicological and health effects of BPA showed a dietary exposure estimates in four population groups as shown in Table 1. The best case[a] in the table assumes only formula fed but no breast milk while the worst case[b] scenario assumes that the daily consumption of 25% packaged food and beverages while the maximum consumption[c] was reported in upper range of exposure estimates.

## 3. Current Practices of Detecting BPA and Other Xenoestrogens

There are various methods of detecting BPA, and the large number of studies citing its presence in the environment suggests that the process is not too complex. Few of the processes that have been defined in the literature, specifically those that are relevant because of their ability to detect many compounds at once, their usability in the field, and their relevance to human exposure are discussed as follows.

### *3.1 HPLC Tandem MS*

Lagana et al. [24] looked at analyzing environmental waters for natural and synthetic steroids. The process involved filtration of river water and then the isolation of the analytes using solid phase extraction with a graphitized carbon black absorbent. Reversed-phase high-performance liquid chromatography and mass spectrometry using atmospheric pressure chemical ionization in the positive ion mode were then performed with the final samples. This method is advantageous because it is a multi-residue technique that can analyze more than one target compound using atmospheric pressure chemical ionization in the positive ion mode were then performed with the final samples. The authors expected that accurate detections could be made at low concentrations on the order of nanograms per liter. Certain analytes had better resolution than others, yet it was felt that a satisfactory level of detection was achieved for the purposes of this study [24]. However, the fact that the authors dealt with synthetic and natural estrogens as opposed to the weakly estrogenic BPA means that this technique may not be as effective for weaker compounds.

**Table 1 Dietary exposure estimates from model diets for four population groups [23].**

| Population | Source of Exposure | Dietary exposure estimate (ug/kg body weight per day) | |
|---|---|---|---|
| | | Mean | 95th percentile |
| Population | Exclusively breastfed | 3 | 1.3 |
| | PC bottles and formula[a] (powder-liquid) | 2.0-2.4 | 2.7-4.5 |
| | Formula, no PC botrles[a] (powder-liquid) | 0.01-0.5 | 0.1-1.9 |
| Infants, 6-36 months | Breastfed + solid food (best case-worst case)[b] | 0.1 | 0.3-0.6[c] |
| | PC bottles and formula[a] + solid food (best case-worst case) [b] | 0.5-0.6 | 1.6-3.0[c] |
| | Formula only, no PC bottles[a] solid food (best case-worst case) [b] | 0.01-0.1 | 0.1-1.5[c] |
| Children, 3+ years | Fruits, deserts, vegetables, meat, soups, seafood, carbonated drinks (best case-worst case) [b] | 0.2-0.7 | 0.5-1.9[c] |
| Adults | Fruits, deserts, vegetables, meat, soups, seafood, carbonated drinks (best case-worst case) [b] | 0.4-1.4 | 1.0-4.2[c] |

[a] no breast milk, assumes formula only; [b] Worst case is assuming the daily consumption of 100% packaged food and beverages, and the best case is assuming the daily consumption of 25% packaged food and beverages; [c] Because of the use of the budget method model, maximum consumption is reported in these upper range of exposure estimates.

*3.2 SPE and GC-MS*

Moors et al. [25] looked at measuring the levels of BPA and other EDCs in human urine using gas chromatography-mass spectrometry. This report not only explored the possibilities of screening for several EDCs at once, but it also elaborated on the importance of monitoring human exposure to BPA and similar substances in order to determine their effects on human. The urine samples were collected, diluted, and stored in BPA-free bottles until the samples were analyzed, and the GC-MS was carried out in total ion mode. In 9 out of 15 samples, BPA was detected between 3 and 55 ng/mL (the limit of detection was < 3 ng/mL). Studies have shown that humans excrete more than 95% of BPA they are exposed to, so this method can be used to estimate exposure. The study also showed that on average, test subjects were excreting 32 μg of BPA per day, or around 0.5 μg/kg body weight (bw), which is well below the tolerable daily intake of 10 μg/kg bw set by the European Union [25].

*3.3 HPLC with Fluorescence Detection*

This study is relevant because it examines the levels of BPA in human breast milk. As newborns are exposed to the chemicals in breast milk, it is especially necessary to be aware of possible EDCs that could affect their sensitive growth. Sun et al. [26] published their findings after looking for ways to increase sensitivities in BPA detection. The breast milk has to undergo several processes with BPA-free water in order to be ready for analysis. Recovery of BPA from milk was found to be 70%, and trace amounts of BPA at 0.28-0.97 ng/mL were determined from 23 lactating women. This method is not simple, as breast milk requires a fair bit of processing before it can be analysed, yet it is an important way to infer the exposure levels of BPA in infants.

## 4. Release of BPA into the Environment

Environmental pollutants often accumulate in our soil (from the application of digested sludge from sewage treatment plants) and our aquatic ecosystems. The potential for biological activity from EDCs should not be dismissed, although their concentrations would be in the range of nanograms per litre. Terrestrial systems are often ignored in research geared towards looking at EDCs sinks, and although the half-life of BPA in soil of only 10 days, it interferes with nitrogen fixation at the roots of leguminous plants since it is associated with symbiotic bacteria Sinorhizobiummeliloti [27]. It is also worth noting that de-activated sludge from sewage treatment plants is often used as a fertilizer, and it is thus possible that contaminant from this sludge could enter the human food chain through absorption into crops. There are several reports which show that many consumer products contain, leach and release BPA under normal conditions of use. BPA has been detected in baby bottles, epoxy resins, consumer plastics products, foods stored in cans with epoxy resins. Wilson et al. [28] reported that BPA could be found in more than 50% of indoor air, hand wipe, solid food and liquid food samples. They also suggested that 99% of exposures of preschool children in the study originated from the diet (52-74 ng/kg/day) and inhalation (0.24-0.41 ng/kg/day). In New Zealand, the exposure of BPA from dietary sources was reported to be as much as 4.8 g/day [29].

As more research is targeted towards detecting BPA and other xenoestrogens in our environment, the focus is gradually shifting towards remediation techniques. Natural remedies such as bioprocesses are often favoured because they are low-cost with lower energy requirements and are generally better accepted by the public. Cabana et al. [30] investigated the effectiveness of using white rot fungi (WRF) and their lignin modifying enzymes (LME) to treat soil and aqueous matrices for the following EDCs: nonylphenol, BPA, and triclosan, as well as certain phthalate acid esters and natural estrogens. WRF produce extracellular enzymes that have low substrate

specificity, which means they can degrade a wide range of compounds such as xenoestrogens. The advantages of WRFs and their LMEs over bacteria include their prevalence in nutrient-deficient soils and their filamentous nature, which allows them to reach deep into soils. Limited nutrient levels are generally what cause the LMEs to be secreted by the fungus, but a variety of environmental conditions such as pH, temperature, and co-contaminants such as salts and heavy metals, may compromise the LME-catalysed removal of EDCs.

For BPA, there are already a wide variety of known gram-negative bacteria that have the ability to degrade this compound in sewage effluent and river water, however using various strains of WRF could target more than just this compound. BPA was removed in a number of ways and at a variety of rates; for strictly WRF treatment, Heterobasiuminsulare and Russuladelica removed 100% after 14 days of incubation, however, other methods involving free laccase and free MnP methods seemed to remove BPA at much faster rates (between 4 and 24 hours) with a 90% removal rate. The paper came to the concerns us that removal of BPA and other EDCs was strain-specific and dependant on a variety of environmental factors. Aqueous solution removal of BPA showed that laccase from Trametes sp. strains could be coupled with injections of oxygen and, thus, a high rate of removal was achieved. This same strain, Trametes sp., was found to be 85% effective at removing BPA from soil after five hours, it was noted that the action of the enzyme and not adsorption to soil particles is what removed the EDCs [30].

## 5. Nonyphenols and Its Environmental Impact

Renner et al. [31] reported that over 500,000 metric tons of nonyphenols are produced worldwide annually, approximately 60% of which will reach to water bodies by various means. Nonyphenol is also considered to be toxic [32]. This has also been found to be estrogenic and inhibited spermatogenesis in adult rainbow trout [33]. Gray and Metcalfe [34] reported that nonyphenols induced sex reversal in Japanese medaka. Nonyphenols have been reported to help proliferate human breast cancer [35]. A study in mice also showed that nonyphenol can cause testicular and ovarian cancer [36].

Nonylphenols are family of compounds consisting of benzene ring and a nine carbon side chain at the center (Fig. 1). Surfactants related to nonyl phenol with ethylene oxide units are called nonyl phenol ethoxylates (Fig. 2).After its release into the environment, nonyl phenol breakdown into nonyl phenol monoethoxylate (Fig. 3) and nonyl phenol diethoxylates (Fig. 4).

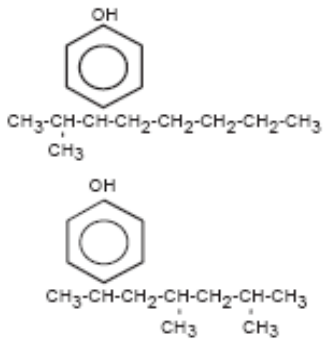


**Fig. 1 Common isomers of nonyl phenol.**

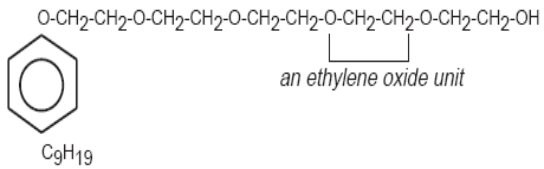


**Fig. 2 Nonyl phenol ethoxylate with 5 ethylene oxide units.**

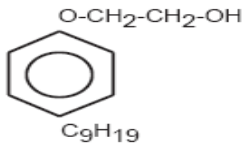


**Fig. 3 Nonyl phenol monoethoxylate.**

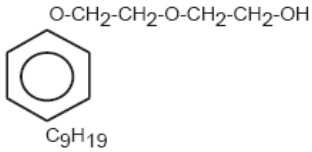


**Fig. 4 Nonyl phenol diethoxylates.**

Cox et al. [27] reported that nonyl phenols and nonyl phenol ethoxylates are acutely causing eye and skin irritation, headaches, nausea, and death if enough exposure occurs toxic. It was also reported that these compounds are also estrogenic [37]. Mimic the action of hormones, reduce the fertility in laboratory animal study and causes breast cancer. Another study suggested that nonyl phenols bioaccumulate in aquatic organisms, inhibit seed germination in some plants and growth of some algae [38]. These compounds persist in the environment for long time [39]. Moreover, nonyl phenol and its ethoxylates have been found in water bodies.

## 6. Natural and Synthetic Estrogens

Estrogen is a homone that can be natural or synthetic. Natural hormone is excreted by women through theirurine, whereas synthetic estrogen is often used as a birth control oral contraceptive. Both of these compounds enter the domestic wastewater system, thereby posing health and environmental risks.

Earlier studies in U.K. found that male fish living in rivers with a significant amount of wastewater discharge were becoming feminized in some cases producing eggs instead of sperm. Subsequent studies found that estrogen in the wastewater were being ingested by male fish causing them to produce egg protein. Addition of about 6 ppt of synthetic estrogen (17a-ethynylestradiol, EE2) used as oral contraceptives, in lake waters, resulted into male fish producing egg protein. According to exotoxicologist, Dr. Karen Kidd of the University of New Brunswick., as male fathead minnow fish were exposed to estrogen in the water, estrogen enters their liver and the liver cells then produce egg proteins [40]. Dr. Kidd further asserts that, “given enough time, estrogen can diminish from a lake water system and the fish populations can recover”. This is so because, synthetic estrogen EE2 can be brocken down by bacteria and sunlight. However, EE2 should still be considered a high risk xenobiotic since it can affect the chemical signaling of both human and fish.

A challenge is that the EDCs are not readily destroyed, they are often dispersed in ecosystem and gradually enter the drinking water supply. Although detection of EDCs is a challenge, researchers have recommended the use of surrogates or flags as indicators to save time and money. Moreover, a true purification rather than treatment techniques are needed to avoid addition of toxic compounds into water and capable to remove the full spectrum of EDCs. Buttlers and Powell [41] reviewed some of the purification techniques as follows: Ozonation under certain conditions can produce bromate, a carcinogen in water [42], reverse osmosis (RO) which is costly cannot remove all EDCs and removes essential nutrients that must later be added.

Use of hydroxyl radical based processes may provide the solution but depend on the method in which the radical is produced. Chemical oxidant such as hydrogen peroxide ($H_2O_2$) has inherent chemical stabilizer which pose another compound of concern. As such, the use of hydroxyl radical solutions also has limitations when dealing with strong EDCs such as pesticides and fire retardants in clothing. Moreover, the total organic carbon in water may contain precursors which promote the formation of regulated compounds (egtrihalomethanes, THMs and haloacetic acids, HAAs) during the purification and disinfection processes. Thus, there is a need to develop or adopt a new purification process. A true purification process is the one that avoids addition of toxicity to the water body and removes most EDCs present in the water or wastewater. According to Buttlers and Powell et al. [41], Purifics Photo-Cattechnology was the most effective process to remove significant amounts of the contaminants listed in Table 2, after water was treated with different advanced oxidation processes shown in Table 3.

The Photo-Cat process also generates an electron for reduction and photogenerated hole, which is a

**Table 2 EDCs detected in north American drinking water study [41].**

| | | |
|---|---|---|
| Pharmaceuticals | Primidone | Progesterone |
| Sulfamethoxazole (Antibiotic) | Gemfibrozil | Estrone |
| Atenolol (beta blocker) | Diclofenac | Estradiol |
| Trimethoprim (antibiotic) | Naproxen (Aleve) | Other Chemical |
| Lopromide (Heart medication) | Octylphenol | Caffeine |
| Fluoxetine (Prozac) | Ibuprofen | Antrazine (herbicide) |
| Meprobamate | Ethynylestradiol (Birth control pill) | TCPP (fire retardant) |
| Dilantin (epilepsy medication) | Personal care products | DEET (Insect repellent) |
| Carbamazeopine | Triclosan (Antibacterial soap) | TCEP (fire retardant) |
| Diazepam | Musk Ketone | Bisphenol A (Plastic) |
| Atorvastatin (Lipitor) | Hormones | BHA (food preservatives) |
| Benzophenone | Testosterone | |

**Table 3 Various oxidizing species [41].**

| Oxidizing species | Relative power |
|---|---|
| Photo-genereted hole on $TiO_2$ | 2.35 |
| Fluorine | 2.23 |
| Hydroxyl radical | 2.05 |
| Atomic oxygen | 1.78 |
| Ozone | 1.52 |
| Hydrogen peroxide | 1.31 |
| Permanganate | 1.24 |
| Hypochlorous acid | 1.10 |
| Chlorine | 1.00 |

stronger oxidant. Thus, there is a need to detect only the main contaminants and treat them, and others will be purified concurrently. This approach will greatly reduce the detection cost and simplifies the associated purification process.

## 7. Synthetic Hormone

Plants generate an array of chemical signals, often known as phytochemicals (also referred to as phytoestrogens). Estrogen signaling in vertebrates and phyto-estrogen signaling from plants have been linked to the symbiotic mechanism with soil bacteria. Xenobiotic synthetic and natural estrogens have been reported to inhibit the nitrogen-fixing symbiosis of *Rhizobium* soil bacteria. For example, leguminous plants such as soybeans and alfalfa secrete phytoestrogens into the soil matrix to induce signals for symbiotic mycorrhizal fungi and *Rhizobium* soil bacteria to provide favorable nutritional growth [43]. Apparently, the most active phytoestrogens observed in plants are considered to trigger breast cancer proliferation in vivo as well as influence the in-situ endocrine function of experimental animals and livestock that feed on high quantities of phytoestrogen bioaccumulated in these plants [44]. Recent genetic analysis somewhat reveal that human estrogen receptors (ERs) and nodulation D protein (NodD) receptors found in Rhizobium soil bacteria have analogous signaling functions and can both respond to similar profile of chemical signals found in the environment. This can possibly be attributed to natural selection while the process of adaptation evolved in similar ecologic and environmental conditions [45].

## 8. Regulatory Issues of BPA

The US National Toxicology Program at the national institute of health and Federal Drug Administration (FDA) have expressed some concerns about the potential effects of BPA on the brain, behavior and prostate gland in fetuses, infants and young children [46]. Based on this study, FDA is taking necessary steps to reduce human exposure to BPA in food supply by supporting industries to stop producing BPA containing baby bottles and infant feeding cups in the US market. The FDA commitment also includes facilitating development of alternatives to BPA for the linings of the infant cans.

The Food Directorate of Health Canada concluded that the current dietary exposure to BPA through food packaging applications is not expected to pose health risk to the general populations, including newborns and infants [47]. However, in the response to widespread public concerns, Canada added BPA on the list of toxic substances and became the first country in the world to ban BPA in baby bottles [48]. Despite the fact that there are significant uncertainties raised based on some animal studies, Government of Canada, recommends that the BPA should be limited to as low as reasonably achievable in all products (ALARA).

## 9. Conclusions

This paper reviews the threats and misconceptions about BPA, nonylphenol and estrogens as EDCs, ways to verify their presence in the environment, andpossible remediation solutions for the future. BPA is one of many compounds that can be leached from plastic containers, and it is through the monitoring of humans and the environment that we can draw conclusions. Man-made chemicals have been reported to mimic endogenous hormones. Nonyphenols (NPs) are also one of the derivatives of alkylphenolpolyethoxylates (APEs) which are widely used as nonionic surfactants. Akylphenolpolyethoxylates are also considered as environmental endocrine disrupters. These chemicals are used in nonionic surfactants and antioxidants in detergents, pesticides, herbicides, paints, cosmetics, and plastic-ware. NPs are toxic, estrogenic, inhibit sperm growth and counts infish, and can cause breast, testicular as well as ovarian cancer.

While politicians can water down the truth and use the influence of large companies to lull the general public into a sense of security from safety, health and environment, scientific studies are undeniable. It is for this reason that chemists, engineers, biologists, and environmental scientists must continue to share information and learn as much as possible about potentially dangerous chemicals so that potential danger from such chemicals can be prevented.

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