



# Potential Impact of Polychlorinated Biphenyls on Plant and Environmental Health

Monika<sup>1</sup> and Abhinav Yadav<sup>1\*</sup>

<sup>1</sup>Department of Environmental Science and Sustainable Development, Banaras Hindu University  
Varanasi, Uttar Pradesh, 221005, India.

## Authors' contributions

This work was carried out in collaboration between both authors. Author Monika designed the study. Author AY managed the literature searches. Both authors read and approved the final manuscript.

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## ABSTRACT

Polychlorinated biphenyls (PCBs) are manufactured natural mixes in which 2-10 chlorine molecules are appended to the biphenyl. They were industrially delivered as intricate blends by the immediate chlorination of biphenyls utilizing anhydrous chlorine. Hypothetically 209 individual PCB mixes are conceivable, however just around 130 congeners have been distinguished in commercial PCB blends. Even though their properties fluctuate over a class, all PCBs are insoluble in water and diligent in both the earth and inside natural frameworks. They are profoundly lipophilic and along these lines tend to bioaccumulate and bio magnify in tissues of living life forms. In view of their concoction and physical solidness and electrical protecting properties, they have had a variety of uses in industry included generally as coolants and greases in transformers, capacitors, and other electrical types of gear. PCBs are present in environment adversely affect the plants properties such as biochemical, physiological, enzymatic and ultimately enters into the human via food chain. This review is an approach emphasizes on potential impact on PCBs on environment.

*Keywords: Polychlorinated biphenyls; environment; bioaccumulation.*

## 1. INTRODUCTION

Polychlorinated biphenyls (PCBs), are synthetic substances produced for a wide range of

electronic scrap, transformers, capacitors, paints, and printing inks and in many other industrial applications [1]. PCB is originating from anthropogenic sources no natural source is

\*Corresponding author: E-mail: [abhinav.evs@outlook.com](mailto:abhinav.evs@outlook.com);

present in the environment but they entered the system through inadvertent spills and leaks during the transport of the chemicals and leaks or fires in transformer capacitors or other products containing PCBs [2]. Dioxin and co planer like PCBs are formed involuntarily in the same way as polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzo-p-furans (PCDDs/PCDFs) [3,4]. Combustion activities are involved in the production of PCB. Most of the persistent organic pollutants (POP) are characterized by deprived water solubility, hence they are resistance to degradation. This results in their environmental persistence over a long time. They may, therefore, accumulate in the soil, partitioned between water and sediment, or exponentially bio-accumulate in the food chain [5]. Sediments are the ultimate sink of POPs like polychlorinated biphenyls through any means of discharge such as industrial, contamination in riverine ecosystem [6]. Contamination in soil stunt the growth of plants and it can be bio toxic for food chain and have a deleterious effect on humans, even relatively low concentrations of PCBs in soils may detrimental for human health [7]. Polychlorinated biphenyls (PCBs) are powerful in the environment due to their persistent nature. Its resilient nature avoids chemical, physical, and biological degradation

[8]. PCB has been transported in long run affecting the region far from the sources for instance [9,10] and Antarctic [11] that is why we termed as long-range atmospheric transport (LRAT) pollutants. LRAT characteristics of pollutants are mainly responsible for a significant amount of presence in rivers and streams after banned [12,13]. Polychlorinated biphenyl (PCBs) directly or indirectly transmitted and contaminate the plant system (Fig. 1). It reduces the plant growth, plant biochemical activity, enzymatic activities, and hamper the microbial biota [14]. It includes Environmental protection agency's (EPA) most hazardous toxicant and is deputed as probable human carcinogens (Group B2). The International Agency for Research on Cancer has determined that PCBs are probably carcinogenic to humans (Group 2A). Stockholm Convention, 2004 was act indispensable year in banning PCB. This convention proved a milestone in reducing and eliminating dirty dozen like PCB. As a part of the Convention, India is legally committed to abide by the targets of the treaty and is encouraged to support research on Persistent organic pollutants (POP). As per the national implementation plan submitted to the Stockholm Convention on Persistent Organic Pollutants, the PCBs have never been produced in India but used in many industrial applications

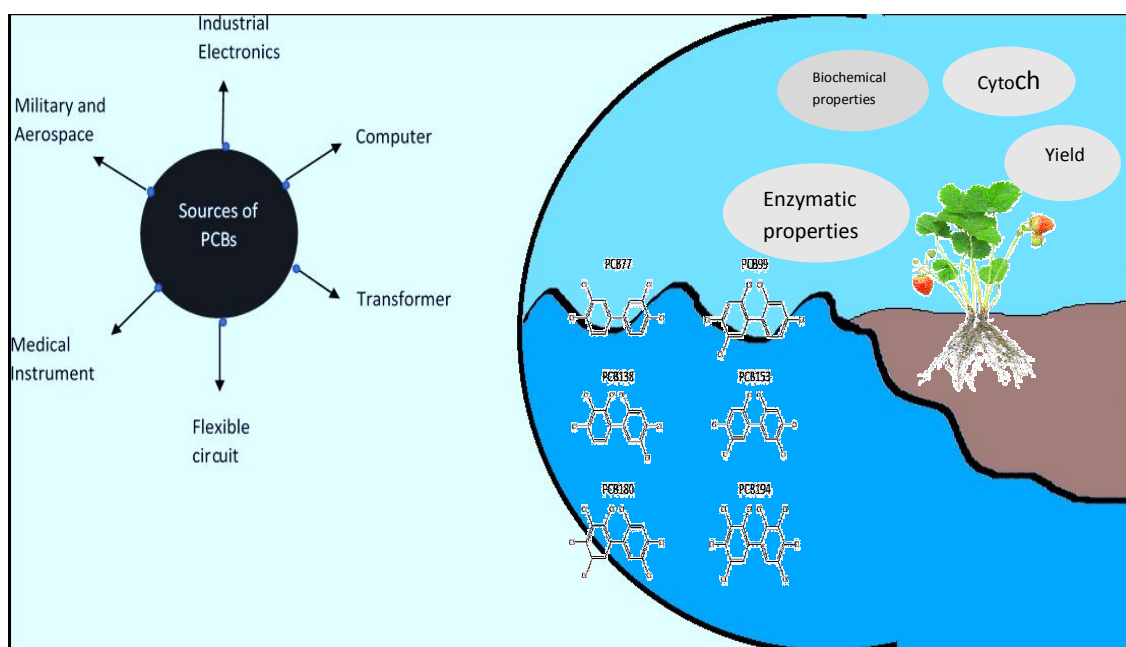


Fig. 1. Schematic diagram of source transmission sink

mainly in the electric transformer. The data conveyed the presence of PCBs in transformer. According to study, around 9837 tons of PCBs exist in the country. There are several studies illustrated the presence of PCB in India rivers [15]; soils [16]; sediments [17,18] atmospheric air [19,20,21], food commodities [22] and biota including humans [20]. Sometimes sources were defined and sometimes it is an effect of LRAT pollutants.

## 2. SOURCES OF POLYCHLORINATED BIPHENYLS

PCB consist of 209 class of chlorinated molecules defined as congeners. The admixture of PCBs has prominently used in industries owing to their high chemical and thermal stability. Potential of PCB elevate its applications in industries for instance plasticizers, dielectric fluids, lubricants, hydraulic fluids in compressors, and flame retardants. PCB become a global issue for the majority of surface and groundwater. It comes in the dirty dozen.

The environmental contamination of Polychlorinated biphenyls (PCBs) was recognized for more than 45 years ago by Soren Jensen in Sweden [23]. Electric plants and Capacitor manufacturing operations contribute a bulk amount of PCB discharge nearby the reservoir. One of the major instances is in Hudson fall and Fort Edward, New York. Over the last few decades, approximately 590,000 kg of PCBs were released into the river [24]. This huge amount of influx shatters the ecological integrity of the river system and posed a solemn threat to human health. Polychlorinated biphenyls dominancy not only register as a global threat but similarly interpret its supremacy in the Indian context also. [25] reported a significant amount of PCB in the river Hooghly and Brahmaputra. The presence of tetra congeners PCBs in surface water and river sediments probably because of atmospheric release of congeners particularly during open burning of municipal solid waste [25]. In River Hooghly, atmospheric deposition might be a conceivable reason for these congeners. However, electronic scraps are unceremoniously recycled in the peripheral industrial belt of Howrah district in the vicinity along the river. A further substantial amount of electronic wastes also ends up in open landfill dumpsites [25]. PCB-169, -189, and -207 were prevalent in the river sediment and water probably because small- and large-scale industries residing on the bank. Large scale

scrap processors dealing in electronic waste scrap from multiple industries are present in this part of Howrah district. [25] result found Geomean of  $\sum_{19} \text{PCBs}$  ( $108 \text{ ng L}^{-1}$ ) was higher in River Hooghly compared with geomean of  $\sum_{19} \text{PCBs}$  ( $77 \text{ ng L}^{-1}$ ) in River Brahmaputra. However, after the Stockholm convention, PCBs have banned and restricted the uses because of their extreme toxicity and persistence in nature. PCBs are still observed as pollutants in natural environments due to their previous usage and long life. These compounds will obstruct biodegradation and endure in condition by connecting emphatically to soil sediment and frameworks, bioaccumulate in life forms particularly at higher trophic level lastly enter the natural food chain [26]. The persistence nature of contaminants poses potential threats to food chain contamination and ultimately human health. The presence of 'artificial' groups such as chloro-, nitro- or sulfonate- in many synthetic chemicals makes them impervious to disintegration as they are not perceived by the degrading microbes.

## 3. IMPACT OF POLYCHLORINATED BIPHENYLS ON PLANTS

The compounds for instance pesticides and PCBs can persist and bio-accumulate by factors up to 70,000-fold in the environment [27]. In a study done by [14] collecting leafy vegetable (spinach, cabbage, lettuce, dhanial, celery, parsley, and kale) and root vegetables (carrots, beetroot, radish, leeks, spring onion, cauliflower, turnip, and broccoli) from several farms in Cape Town. There were 6-PCBs congeners:

1. (PCB<sub>110-2</sub>, 2', 4, 4',6-pentachlorobiphenyl);
2. PCB<sub>118-2</sub>, 3', 4, 4', 5-pentachlorobiphenyl);
3. PCB<sub>138-2</sub>, 2', 3, 4, 4', 5-hexachlorobiphenyl);
4. PCB<sub>149-2</sub>, 2', 3, 4', 5', 6-hexachlorobiphenyl);
5. PCB<sub>153-2</sub>, 2',4, 4',5, 5'-hexachlorobiphenyl);
6. PCB<sub>180</sub> (2, 2', 3, 4, 4', 5, 5'-heptachlorobiphenyl) detected.

According to the result illustrated (PCB<sub>110</sub> congener, 200ng/g) was detected maximum in all leafy vegetable and (PCB<sub>138</sub> congener, 119 ng/g) detected least. In root plants, cauliflower has minimum PCB congener and carrot reported antagonist in accumulation. The study concluded

the less chlorinated uptake rapidly because of the high bioaccumulation factor.

#### 4. PCB IMPACT ON HUMAN HEALTH

Humans are widely exposed to hazardous substances via three main routes: inhalation, ingestion and dermal contact [28]. We assessed the total exposure to these substances at waste or e-waste recycling sites in India, and compiled published data about main intake routes. Exposure to such substances is possible either directly or indirectly, by inhalation or food ingestion, from soil and dust contaminated by waste materials. PCBs develop detrimental effect on neurological system of children and infants. It can induce deficits in memory, abnormal reflexes and diminishes learning and IQ (intelligence quotient) ability [29]. There are number of epidemiological studies proved neuro development toxicity in children whose mother exposed to PCBs contamination via any means food, water or air. Level of PCBs elevated in milk and maternal serum are in direct connection with consumption of fish [30]. According to De Rosses et al. [31] population-based case-control experiment performed in the United States for investigating how exposure to PCBs might affect the risk of non-Hodgkin's lymphoma. Some significant PCB congeners, specifically those PCBs have higher chlorinated percentage like (PCB 156, 180, and 194) were associated with elevated risk of non-Hodgkin's lymphoma development [30].

#### 5. PCBs IMPACT ON ENVIRONMENT

These synthetic compounds were prohibited in the U.S. in 1979 in the midst of recommendations that PCBs could impacts affect human and natural wellbeing. From the 1920s until their boycott, an expected 1.5 billion pounds of PCBs were made for things, for example, magnifying instrument oils, electrical covers, capacitors, and electric machines, for example, TVs or fridges. PCBs were likewise showered on earth streets to hold the residue down preceding knowing a portion of the unintended results from inescapable use. Preceding the boycott in 1979, PCBs entered the air, water, and soil during assembling and use [32]. Contamination in soil through PCBs leads deprive growth of plants and bio accumulates in food chain [33,34]. The amount of distribution of PCBs in soil can help to assess the level of pollution, infer the source of the emission and evaluate the human health risk

[35]. Experiment had performed study on 7 PCBs congeners (PCB28, PCB52, PCB101, PCB118, PCB138, PCB153, PCB180) in suburban vegetable soils and estimated the noncarcinogenic and carcinogenic risk of PCBs pollution to exposed population of Changchun area, Northeast China. Experiment based on 106 urban vegetable soil samples Changchun City, Nongan County, Dehui City, Yushu City, Jiutai City [36]. Results concluded that total concentrations ranged between 1.31 to 148 ng/g dry weight (dw) with a mean value of 42.0 ng/g. Principal component analysis (PCA) illustrated that main source of PCB comes from transportation, vehicular emissions, paints and other industries. According to Human health risk assessment, cumulative non-carcinogenic and the cumulative carcinogenic risk in children and adults in the industrial land and residential land were acceptable but it could be higher in coming future. There are natural, human wellbeing, and money related worries with these other options.

Several studies verified the presence of PCB is ubiquitously present in most of the polluted river [25,37]. Hudson is one of the polluted rivers in the USA. Experiment based on the application of vegetable soil mixed polluted river sediment amended in cucumber with the percentage of 0%, 10%, 25%, 50%,75%, 100% respectively. The result found cucumber biomass yield maximum in lower amended soil than control soil (Table 1) [37]. 25% sediment admixture amendment led to considerably higher biomass yields: 125% of control value for the stem and 129% for the leaves. Higher doses of amended soil restrict biomass production. The 75% admixture produced 70% stem biomass and 82% leaf biomass compared to controls. 100% admixtures amendment has reduced the yield by 22% stem and 23% leaf biomass (Table 1). Also, the mean leaf surface area was significantly higher only in variant amended with 25% of sediment: 119% of the control value. The application of 100% sediment resulted in leaves with only 38% of control values. Application of a higher dose showed a destructive effect on chlorophylla and b content. 10% dose promotes the significant growth of phenylpropanoid and flavonol contents in plants amended with lower dose soil, but considerably drop down in soil treated with a 100% sediment admixture. A similar result found with anthocyanin content in plants was deepens at admixtures of 50% and higher [38].

**Table 1. Different studies based on PCB effect on plants**

Study site	Study plant	Effected part in Plant	References
Southern China	Eucalyptus and Pine Plants	Cytochrome P-450 Enzymes in leaves	[39]
Cape Town, South Africa	Leafy vegetables (spinach, cabbage, lettuce, dhanial, celery, parsley and kale) and root vegetables (carrots, beetroot, radish, leeks, spring onion, cauliflower, turnip, and broccoli)	Uptake in plants and majorly accumulation in leaves	[14]
New York, USA	Cucumber	Biomass yield Soil Enzyme (Phenyl propanoid, Anthocyanins)	[37]
Pennsylvania, USA	Thale Cress	Germination rate, Plants growth, Cytochrome 450, Glutathione	[40]

The obtained results corresponded with the decreasing content of N and K.

## 6. CONCLUSION

PCBs in our environment are not an innovative phenomenon, but instead an old injury and nature must bargain with it. PCB present in our environment mainly due to human negligence and anthropogenic activities. It is pressure on private industry and administrative associations to manage the issue viably that appears to work best. Organizations that delivered these poisons years back are hesitant to pay for their cleanup now. The transmission of PCB in the terrestrial area depends on various factors, for instance chemical properties, the properties of the soil in which they are present, and the characteristics of the plants exposed to them. Exposure of PCB reduces plant growth, biochemical activities, Enzymatic activity. Abnormalities of growth and chlorosis occur in plants in some cases less percentage amended soil showed a positive effect on plants, but higher amount amendment showed the deleterious impact. PCBs can diminish chlorophyll content and may affect photosynthesis, possibly at PS II, and may also uncouple respiration. This review concluded with PCB has many hazardous effects on plants and it ultimately reaches in the food chain and affects human health risk. Continuous monitoring of PCB should be necessary in agriculture related water uses and suitable steps for amelioration in water and soil. This step should reduce the risk of contamination to some extent.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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