CHAPTER 1
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1.1 General

Pesticides give a major input in modern agriculture (Oudejans, 1994). It includes both synthetic and natural occurring substances which are used to control the pests like insects, plant disease organisms and weeds, they also include various organism such as nematodes, arthropods and vertebrates that imperil our food supply, health or comfort. In particular, the term pesticide refers to chemical substances that are biologically active and interfere with normal biological processes of living organisms deemed to be pests, whether these are insects, mould or fungi, weeds or noxious plants (Damalas, 2009). Mostly pesticides are used in crop production to reduce infestations by pests and protect crops from impending yield losses and decreasing of product quality.

Pesticides are used since past many years, when during ancient time’s rulers and kings used toxic pests and compounds to kill their enemies. The consequences were not found good due to its crude chemicals and the inappropriate technique used. After World War II the use of pesticides were increased rapidly with the introduction of DDT (dichlorodiphenyltrichloroethane) by Paul Muller, to control malaria and typhus among civilians and troops. After the war, use of DDT started as an agricultural insecticide and then onwards its production and use duly increased (Damalas, 2009; WHO, 1979). Hundreds of new synthetic chemicals of varying toxicity have been introduced by recent research and development. These chemicals not only provide benefits in crop production,
but also act as a source of environment pollution and exposure to the pesticides could also cause negative consequences for human health (Anwar, 2008).

Since three decades human take benefits of these agro-chemicals without knowing their ill effects (Asmatullah, 1996). In 1962 Carson’s published a book ‘Silent Spring’ which described the environmental impacts of DDT spraying in the United States. The book states that DDT and other pesticides were not only responsible to cause cancer but their agricultural use was a danger to wildlife, particularly bird. Publication play seminal event for the environmental movement and resulted in a large public outcry that eventually led, in 1972, to a ban on the agricultural use of DDT in the United States (Lear, 2009). Many other synthetic insecticides such as organophosphate (OP) in 1960s, Carbamate in 1970s, pyrethroids in 1980s, herbicides and fungicides in 1970s–1980s were also introduced. These insecticides not only control pest but also contributed greatly in agricultural output (Aktar et al., 1958).

In early 1940’s the use of pesticides in agriculture (for the control of disease vectors) has increased dramatically throughout worldwide. In developing countries, 25% of pesticides are being consumed mainly on cash crops. Insect killers were used in million (around 2.5 millions) by farmer all around the world, which is continuously increasing with the passage of time (Pimentel, 1995; FAO, 2002).

First time in 1952, the production of pesticides started in India, with the plant for the production of Benzene hexachloride (BHC) was established near Calcutta. Since then, after China the second largest manufacturer of pesticides in Asia is India and globally it rank twelfth (Mathur, 2010). At present, nearly 150 pesticides are registered with legal application in India (Bhardwaj et al., 2013). From 1953-54, the average per hectare
consumption of pesticides in agriculture was 1.2\,gha^{-1} in India which augmented to 377\,gha^{-1} in 1985-86 and cultivated to 431\,gha^{-1} in 1992-93. However, in 1999-2000 there was a gradually decline (288\,gha^{-1}) in fertilizer consumption (Agnihotri, 2000). According to one estimate, every rupee invested in chemical pest control returns Rs 3 in crops saved (NCAER, 1967), while as per another estimate one rupee spent on chemical control of pests can fetch Rs 7 to Rs 26 by managing huge losses on crops like cotton, paddy, sugarcane, sunflower, mustard, vegetables and groundnut (Bakhetia and Udean, 1998). According to crop wise, cotton consume highest share of pesticide i.e. around 37\% followed by paddy (20\%). In India together they account for about 57\% of the total pesticide utilization. While the wheat and pulses consume about 4\%, vegetables about 9 \% and the other plantation crops about 7 \% (Ministry of Agriculture, 2009). According to the report, the pesticide conception is maximum in Andhra Pradesh state (23\%) followed by Punjab & Maharashtra (Bharat Book Bureau, 2006). Cheap compound that are existing in environment and used in agriculture are banned these days in developed countries, but due to their low cost and flexibility in agriculture, industry and public health their remain popular in developing countries (Carvalho et al., 2006). Farmers use pesticides beyond the prescribed dosages out of their ignorance or considering that pesticide formulations are adulterated and does not have mentioned active ingredient. The injudicious use of pesticides like dipping in insecticide solution or spraying before the crop is harvested, use of spray cocktails/mixtures and use on other than recommended crops is not uncommon (Felding, 1992). In 1958 first case of lethal death was recorded in Kerala, India. Due to the consumption of wheat flour contaminated with parathion. Every year 25 million farmers are suffering from poisoning compounds used in agriculture. The progression of lethality prolonged with numerous incidences such as Bhopal MIC tragedy & latest, Saran district (Bihar). Study observed
that due to the consumption of Monocrotophos more than 30 children were died. Moreover large number of cases was recorded due to long term exposure even at low level also causes serious health problems like immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer. According to the research data the reason behind it was that only 0.1% of pesticides are used to control pests while remain 99.9% percolates in the environment like soil and water (Bhardwaj and Sharma, 2013). Insecticides used by farmers in agriculture are mostly engrossed and tarnished in the top soil, however the pattern of use of some persistent pesticides combined with the environmental condition could involve a risk of leaching that leads to increased risk of water contamination. Soil is also considered as a potential pathway of synthetic compounds transport to pollute water, air plants, food and finally the living beings (Abrahams, 2000; Ahmed et al., 2007; Anwar, 2008). The transportability of synthetic compounds in soil, and thus their persistence and shifting to other ecological compartments (the atmosphere and water bodies), determined by their mechanisms and kinetics of their sorption on and desorption from the soil particles (Moorman et al., 2001). Extreme and unacceptable use of pesticides in agriculture is contaminating the water sources by leaching, runoff, careless disposal of empty containers, equipment washings, etc. from the farm fields. Ecological infectivity of natural waters by pesticide residues is of huge anxiety these days (Kolpin et al., 1998). Over the years, many pesticides have been evaluated and for several of them a substantial leaching of residues was considered to be possible. In particular, leaching of pesticides from agricultural practices into the water bodies is receiving greater attention because of the enormous importance of groundwater in human life as it represents about 98% of the available fresh water of our planet (Fenoll et al., 2011). In developing countries 30% of insecticides which were sold in markets do not
confirm to the international quality standards and thereby entail potential risk to the environment, animal and human health (Karabasanavar et al., 2012).

In several studies it has been observed that the pesticides used in our country where no pre-harvest time frame after application is maintained. The most frightening thing is that in India the use of pesticides is very indiscriminate. There are vicinities where pesticides are used in extreme amounts and in such a circumstance the observing and evaluation of pesticide pollution becomes very complicated. Many of these pesticides eventually reach the soil following field application, even when sprayed on the foliage of crop plants and weeds. Once introduced in the agricultural ecosystems, the pesticides may get transported to other parts of the environment where they can cause side effects (Cerejeira et al., 1995). Direct or indirect application of the pesticides may result in an accumulation of their residues in soil (Redondo et al., 1997). Information regarding the residues of pesticide in water bodies is scanty. However, currently fewer case studies are noticed regarding the human health status cause due to water resources. The jeopardy of water contagion by pesticide residues or by other compound has been unobserved over the years, since the surface layer of soil has always been considered as an effective sieve to avoid deep water pollution (Stara et al., 1986). A statement behind the lack of anxiety has been that the pesticides applied per unit area is of relatively low concentration and, as such, they would either be disgrace very quickly or tied to soil particles (Helling and Gish, 1986). However, current studies have established that the risk of pollution is real and that the routes through which chemical filtrate can reach groundwater are complex and dependant on various internal and external factors, such as rain frequency, residue solubility, physicochemical characteristics of the chemicals involved, and chelation or precipitation phenomena (Smith et al., 1987), as well as on the distribution and fate related properties of the soil such as pH,
cation-exchange capacity, buffering capacity, particle size, redox-potential, temperature, type and amount of clay minerals, biological activity and biomass, amount of organic matter, hydrological properties, and macropores. According to Indian standard, all the residues of insecticide should be lacking in drinking water (ISI, 1991). However, according to EEC Directive 80/778 (EEC, 1998) the essence of water for human utilization established the maximum concentration of each pesticide at 0.1 µgL$^{-1}$ and the total pesticide concentration at 0.5 µgL$^{-1}$ (Vettorazzi, 1979). Such an over reliance on the use of pesticides in crop protection in general and crop agro ecosystem in particular reflects on the attitude and concepts being developed by masses and short coming in our pesticide policy. As the government understands the gravity of misuse, it should review its policy for the safe and effective use of pesticides in a realistic economic frame work, which incorporates health risks and environmental concerns associated with its usage. This would help in reducing the pesticide usage to an optimal level that can be accepted by both the society and the farmers. For this purpose a project was executed to analyze the existing policy that suggested further reform for excessive use of pesticides in the developing countries including India (FAO, 2001). It is necessary to take into account the whole intake of pesticides both in crops and water bodies. One of the key difficulties that may be faced by the developing countries in assessing the potential health may be the method of spraying pesticides used by farmers in crop fields (i.e. cocktail/mixture formation). This problem could be illustrated by the reference to pesticide residues in water bodies and that may contain residues of different types of pesticides. Therefore, in view of poisonous and dangerous nature of pesticides, an endeavor has been made to analyze the pesticide pollution in surface and groundwater due to their use by farmers in crops (vegetables, rice and cotton) growing areas of selected states of India.
The major aim of the study was to estimate the extent of contamination of organochlorine, organophosphorous pesticides and synthetic pyrethroids in surface and groundwater due to their use by farmers in cotton, rice and vegetable crops in selected states of India. Following objectives were taken to achieve this major aim:

1.2 Research objectives

- To know the pesticide usage pattern in vegetables, rice and cotton growing areas in Delhi, Uttar Pradesh and Haryana respectively.

- Estimation of the pesticide residues in water bodies (surface and groundwater) in vegetables, rice and cotton growing areas of Delhi, Uttar Pradesh and Haryana.