CSE/PML-6/2002

Analysis of pesticide residues in bottled water

[Delhi region]

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DATE:

January 2003

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1. ABOUT CSE LABORATORY

The Centre for Science and Environment, a non-governmental organization based in New Delhi, set up the Pollution Monitoring Laboratory to monitor environmental pollution. The laboratory aims bring science out into the public domain; it undertakes scientific studies to generate public awareness about food, water and air contamination. It is equipped with state-of-the-art equipment to monitor and analyse air, water and food contamination: High Performance Liquid Chromatograph (HPLC), Gas Chromatograph (GC) with ECD, FID and other detectors, UV-VIS Spectrophotometer, Mercury Analyzer, and Respirable Dust Sampler among others. It provides scientific services at nominal cost to communities that cannot obtain scientific proof of local pollution. Given the state of scientific research in India -- most of it restricted to national defense and food security -- the laboratory is an effort to use science to achieve ecological security.

2. EXECUTIVE SUMMARY

Pure drinking water is a luxury in India today. Most water sources are contaminated; water borne diseases such as diarrohea, dysentery, typhoid, jaundice and gastroenteritis are legion. Even the municipal water supply is not free of contaminants like pesticides, and heavy metals. People either boil water to drink it or install purifiers. Of late, they have also turned to bottled water available in the open market: this water is perceived as safe. Given human dependence on water, we cannot afford to be careless about the kind and quality of water, that we drink.

Various top brands like Bisleri, Kinley make claims about the purity of their mineral water and advertise their water as the safest. But the source of water for different bottlers is bore-well (groundwater). Given the quality of water in and around Delhi is not very good, could bottled water, too, be contaminated? Could bottled water contain pesticides, since it is known that Delhi’s groundwater does?

Since exposure to pesticides through drinking water has potential health effects, a study was undertaken to assess the quality of bottled mineral water in terms of pesticide levels. Do various brands conform to standards specified by the Bureau of Indian Standards (BIS) and Prevention of Food Adulteration Act, 1954 (PFA)? How do the brands — and the norms themselves — fare when compared to internationally accepted drinking water norms, such as that of the World Health Organization or the US Food and Drug Administration for pdrinking water?

The laboratory collected 2 bottles each of 17 bottled drinking water brands — the top five brands such as Bisleri (Aqua Minerals Ltd), Bailley (Parle Agro Pvt. Ltd), Pure Life (Nestle India Ltd), Aquafina (Pepsico India Holding Pvt Ltd) and Kinley (Hindustan Coca Cola Beverage Pvt. Ltd) and other less popular brands — being sold in Delhi and nearby Gurgaon and Meerut. The bottles were randomly purchased. They were then analysed for 12 organochlorines and 8 organophosphorus pesticides using a method called gas chromatography (GC). The testing process was based on the United States Environment Protection Agency testing procedure for pesticides in drinking water.

In the BIS drinking water standards, the desirable limit for pesticides is given as “absent”. The permissible limit, in the absence of any other alternate source is given as 0.001mg/l (1µg/l). The BIS standard for packaged drinking water — IS 14543:1998 — and Natural Mineral Water — IS: 13428:1998 — covered under the relevant PFA states that pesticide residues “should be below detectable limits” when tested in accordance with the relevant methods. However, when tested for organochlorine pesticides and organophosphorus pesticides, the water bottled by the 5 top brands and other less popular brands were found to be contaminated with pesticide residues.

Among the organochlorines, HCH and DDT were frequently detected. γ isomers of HCH (Lindane) were detected in 94 per cent of all samples. DDT was detected in 70.6 per cent of the samples. Metabolites of DDT like DDE and DDD were also detected. Endosulfan was present in 8.8 per cent of the samples. Among the organophosphorus pesticides, Malathion and Chlorpyrifos were most frequently detected: respectively, in 85.3 per cent and 82.4 per cent of the samples.

People switch over from tap water to bottled water because they think it is not contaminated. The CSE laboratory test shows otherwise. Bottled water should not be considered a sustainable alternative to tap water. Source monitoring, reduction in use of pesticide and effective treatment seems to be the best choice for keeping a check on pesticide concentration in water.

3. INTRODUCTION & ORIGIN OF THE STUDY

Keeping in mind consumer interest and public health, the Union Ministry of Health and Family Welfare issued a notification on September 29, 2000 for all packaged water manufacturers and traders, according to which ISI certification from Bureau of Indian Standards was made mandatory. According to BIS about 517 packaged water companies obtained the BIS certification as per IS 14543:1998 for packaged drinking water (other than packaged natural mineral water). Six in the natural mineral water category have obtained the mandatory ISI certification for packaged Natural Mineral Water as per IS 13428:1998. Although BIS has provided standards for various physical and chemical parameters in the drinking water, these standards do not give maximum residue limits (MRL) for individual pesticides. The standards for total pesticides are also not quantified. The limit “below detectable level” is vague and ambiguous.

Since pesticides are harmful to human health — they have acute or immediate effects resulting from short-term exposure, like nausea, lung irritation, skin rash, vomiting, dizziness, and even death and chronic effects that occur long after repeated exposure to small amounts of a chemical which include cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system, and birth defects — this oversight is surely a grievous one.

Part of the water supplied to Delhi is groundwater and the other part comes from the river Yamuna. In fact Delhi receives 70 percent of its water from the Yamuna. A number of researchers have reported pesticides and heavy metals in drinking water and groundwater in different parts of the India (Bouwer H, 1989; Dikshit TSS *et al*, 1990; Jani JP *et al*, 1991; Kumar S, 1995; Bansal OP and Gupta R, 2000). However, there are no studies on pesticides in bottled water. As exposure to pesticides through drinking water may have potential health effects, the laboratory decided to take up a study to analyse the presence of organochlorine and organophosphorus pesticide residues in bottled water marketed in Delhi and its adjoining areas.

The test results were compared to the standards for permissible limits for individual and total pesticides prescribed by European Economic Community's EEC Directive 80/778/EEC, which gives quantified limits for pesticide residues unlike BIS. This Directive provides 62 parameters on "quality of water intended for human consumption", and is used as a norm at European level. In the Directive, parameter 55 sets the limit for how much of a particular pesticide and all pesticides taken together can be allowed to exist in drinking water. It sets the maximum admissible concentration at 0.1 microgram's per litre (µg/l) or 0.0001 milligrams per litre (mg/l) for individual pesticide and 0.5 microgram's per litre (µg/l) or 0.0005 milligrams per litre (mg/l) for total allowable pesticide residue.

4. ABOUT BOTTLED WATER

4.1. International Scenario

The world bottled water market amounts to an annual volume of 109 billion litres, an average 17.5 litres of bottled water drunk yearly per person (Zenith International, International Council of Bottled Water Association, 2000). Western Europeans are the major consumers, with an average of 93 litres/person/year. Asians presently consume the least. Thus there exists a vast potential market for bottled water in Asia.

Nestle, a leading player of bottled water in the world market with a turnover of about US $ 3.5 billion in 1999, represents 15.3 per cent share of the world market. Nestle owns well known brands in 17countries, like Perrier, Contrixor, Vittel (France), Arrowhead, Poland Spring, Calistoga (United States), and San Pelligrino (Italy). Danone, a French group, holds 9 per cent of the world market share and boasts of powerful brands such as Evian, Volvoic and Badoit (Ferrier C, 2001)**.** Pepsico's Aquafina launched in 1995 in the USA had a turnover of US $ 600 million (Bellot L, 2000).

According to a 1999 Natural Resource Defense Council (NRDC) USA report, 40 per cent of the bottled water is derived from tap water. Pepsico's Aquafina label read: "picture beautiful stylized mountains". However, the water was actually municipal tap water derived from 11 different city and town water supplies. One brand advertised as "pure glacier water" uses public water supply and another touted as "spring water" pumped water from a parking lot next to hazardous waste (Olson E, 1999). According to the report, tests were conducted on 1000 bottles of 103 brands; it was found that bottled water was generally safe to drink. However, one fourth of the bottled water violated the quality limits enforced by the government. About one third of the bottles tested showed the presence of contaminants like bacteria, industrial chemicals, algae and excessive chlorine. About one fifth of the water contained synthetic organic chemicals such as industrial chemicals (toluene, xylene, isopropyl toluene), chemicals used in manufacturing plastics (phthalates, adipate, styrene) and tri halomethanes (cancer-causing by-products of water chlorination), but at levels below the standards prescribed by the federal government or state government. Arsenic, a known human carcinogen, was detected in 8 percent of the samples and was above the prescribed limits. In 1990, Perrier had to withdraw 280 million bottles from 750,000 sale points in the world because of benzene concentrations above US standards (8-17µg, instead of 5 µg) (Olson E, 1999).

Recently the USEPA reported that almost 10 per cent of community tap water system violated federal EPA tap water treatment or contaminant standards. Of this, 28 per cent violated significant water quality monitoring or reporting requirements. Significant levels of contaminants such as cancer-causing trihalomethanes, radon and arsenic were detected in the tap water (NRDC, 1995)(4). FDA (Food and Drug Administration) rules for bottled water are often weaker than USEPA regulations applying to big city tap water; bottled water is required to be tested less frequently than city tap water for bacteria and chemical contaminants. In particular, tests for coliform bacteria are done once a week for bottled water as compared to an average 100 times per month for tap water; tests for organic chemicals such as industrial chemicals, some pesticides and trihalomethanes are done four time a year for tap water, once a year for bottled water (Olson E, 1999). Eleven of the 29 European brands of mineral water were found to be contaminated with Norwalk like virus or NLV, and human faeces were contaminating the water either at the source or some time during the bottling procedure (Beuret C et al, 2000).

4.2. Indian Scenario

4.2.1. The bottled water market

The Rs 1000 crore bottled water industry is growing at the rate of 40 per cent annually (Business Today, 2001). Under the BIS certification scheme, about 517 licenses for packaged drinking water have been issued in the country as per IS: 14543:98. BIS has granted 6 licenses for packaged natural mineral water as per IS: 13428:98 including one license in France under foreign manufactures (Malik PP, 2002).

At the forefront are Bisleri, Bailley, Yes, Kinley and Aquafina. There are numerous other regional and local brands across the country, meeting local demands. Many multinationals have entered the market and have increased the marketing activity to tap the unexploited potential. Most of the brands compete in a very narrow market segment, comprising predominantly the travel, tourism, caterers, restaurants, and hospital segments. The attention is now focussed on tapping the vast potential presented by entry into affluent / upper middle class households. The bottled water market share of major brands is captured by Bisleri (51 per cent), Bailley (17 per cent), Yes (11 per cent) followed by Kinley (10 per cent) and Aquafina (4 per cent) (Source: BT Estimates June, 2001). In the natural mineral water sector Evian, Perrier, Catch, and Himalayan are the major brands.

4.2.2. Product Certification

BIS operates a product certification scheme under which licences are granted to manufacturers who wish to claim conformity of these products to relevant Indian Standards. It enables manufacturers to use the Standard Mark (popularly known as ISI Mark) under BIS Act 1986. The scheme was voluntary in nature and aimed at providing third party assurance to the customer. Then on September 29, 2000 the Union Ministry of Health and Family Welfare issued a notification [No. 759 (E), effective from 29.3.2001]. An amendment to the Prevention of Food Adulteration Rules 1954, the BIS certification Mark is now mandatory for packaged drinking water and packaged natural mineral water.

Separate standards have been formulated for packaged drinking water (IS 14543: 98) and for packaged natural mineral water (IS 13428:98). These standards give parameters to be tested and the requirements to be met in respective category of packaged water. Table-1 includes standards for physical and organoleptic parameters, general parameters, parameters concerning toxic and radioactive substances and pesticide residues.

Besides the parameters in Table-1 microbiological parameters such as *Escherichia coli* (thermotolerant bacteria), Coliform bacteria, Faecal *Streptococci, Staphylococcus aureus, Pseudomonas aeruginosa,, Yeast, Mould, Salmonella, Shigella, Vibrio cholera, Vibrio parahaemolyticus* are also required to be periodically tested in the in-house laboratories.

4.2.3 Difference between Packaged Natural Mineral and Packaged Drinking Water

Packaged Natural Mineral Water: According to BIS natural mineral water is obtained directly from natural or drilled sources like spring artesian well, drilled well or from an underground water-bearing strata for which all possible precautions should be taken with in the protected perimeters to avoid any pollution of, or external influence on, the chemical and physical qualities. It is characterized by its content of certain mineral salts and their relative proportion and the presence of certain trace elements of other constituents. It is required to be collected under conditions, which guarantee the original natural bacteriological purity and chemical composition of essential components and is bottled at the point of emergence of the source under hygienic conditions. It is not subjected to any chemical treatment such as pasteurization, ionization, or ozonation. The packing of natural mineral water has to be done at the place of the source water only and transport of unpacked water in bulk is not permitted. There are only 6 packaged natural mineral water brands in India — 5 in the Northern Region (Himalayan, Catch, Hello Blue, Total Z and Life Spring) and 1 under the foreign manufacturers scheme, namely Evian imported from France.

Packaged Drinking Water: Most of the bottled water brands come in the category of packaged drinking water which according to BIS is derived water filled in hermetically sealed containers of various compositions, form, and capacities that is suitable for direct consumption without further treatment. It is subjected to treatment: decantation, filtration, combination of filtration, aeration, filtration with membrane filters, depth filter, cartridge filter, activated carbon filtration, demineralization. It is disinfected to a level that will not lead to harmful contamination in the drinking water.

TABLE-1: Difference Between Packaged Natural Mineral Water and Packaged Drinking Water

S. No.	Parameter	Packaged Natural Mineral water	Packaged Drinking water
1	**Definition**	It is obtained directly from natural or drilled sources from underground water, bearing strata for which all possible precautions should be taken with in the protected perimeters to avoid any pollution of, or external influence on, the chemical and physical qualities.	Drinking water filled in hermetically sealed containers of various compositions, form, and capacities that is suitable for direct consumption without further treatment.
2	**Standard**	Indian standard IS: 13428:98 Packaged natural mineral water specifications.	Indian standard IS: 14543:98 Packaged drinking water (other than Natural mineral water) specifications.
3.	**Treatment**	It is not subjected to any treatment other than those in IS:13428:98 for Natural mineral water. Treatments permitted include separation from unstable constituents, such as compounds containing iron, manganese, sulfur or arsenic by decantation and/or filtration, if necessary, by previous aeration.	It may be subjected to treatments, namely, decantation, filtration, combination of filtration, aeration, filtration wit membrane, filters, depth filter, cartridge filter, activated carbon filtration, demineralization, reverse osmosis.
4.	**Organoleptic and physical parameters**	**Requirement**	**Requirement**
	Colour (Colour units)	2	2
	Odour	Agreeable	Agreeable
	Taste	Agreeable	Agreeable
	Turbidity(NTU)	2	2
	Total dissolved solids mg/l	150-700	500
	pH value	6.5-8.5	6.5-8.5
5.	**General Parameters Concerning substances undesirable in excessive amount**	**Requirement**	**Requirement**
	Nitrates (as NO3) mg/l	50	45
	Nitrite (as NO_2) mg/l	0.02	0.02
	Sulfide (as H_2S) mg/l	0.05	-
	Manganese (as Mn) mg/l	2.0	0.1
	Copper (as Cu) mg/l	1.0	0.05
	Zinc (as Zn) mg/l	5.0	5
	Iron (as Fe) mg/l	-	0.1

	Flouride (as F) mg/l	2.0	1.0
	Barium (as Ba) mg/l	1.0	1.0
	Antimony (as Sb) mg/l	0.005	-
	Borate (as B) mg/l	5.0	-
	Silver (as Ag) mg/l	0.01	0.01
	Aluminium (as Al) mg/l	-	0.03
	Chloride (as Cl) mg/l	200	200
	Residual free chlorine mg/l	-	0.2
	Sulfate (as SO_4) mg/l	200	200
	Magnesium (as Mg) mg/l	50	30
	Calcium (as Ca) mg/l	100	75
	Sodium (as Na) mg/l	150	200
	Alkalinity (as $HCO_{3)}$ mg/l	75-400	200
	Selenium (as Se) mg/l	0.05	0.01
	Mineral oil mg/l	Not detectable	0.01
	Phenolic compounds (as C_6H_5OH)	Not detectable	0.001
	Anionic surface active Agents (As MBAS) mg/l	Not detectable	0.2
6.	**Parameters concerning Toxic substances**		
	Arsenic (as A) mg/l	0.05	0.05
	Cadmium (as Cd) mg/l	0.003	0.01
	Cyanide (as CN) mg/l	0.07	0.05
	Chromium (as Cr) mg/l	0.05	0.05
	Mercury (as Hg) mg/l	0.001	0.001
	Lead (as Pb) mg/l	0.01	0.01
	Nickel (as Ni) mg/l	0.02	0.02
	Polychlorinated Biphenyls (PCB)	Not detectable	Not detectable
	Polynuclear Aromatic Hydrocarbons	Not detectable	Not detectable
7.	**Parameters concerning radioactive residues**		
	Alpha emitters Bq/l *Max*	0.1	0.1
	Beta emmiters pCi.l , *Max*	1.0	1.0
8.	**Pesticide Residues** Given in section 6.3. As covered under the relevant Rule of the Prevention of Food Adulteration Act, 1954	**Below detectable limits**	**Below detectable limits**

4.2.4. Licensing Procedure

A manufacturer is granted licence to use the standard ISI Mark after assessment of the infrastructure facilities for manufacturing, and quality control checks to produce goods of consistent quality as per relevant standards. The manufacturer is required to have in-house testing facilities to carry out frequent tests as given in BIS document called Scheme of Testing and Inspection. The in-house quality control laboratories conduct a number of on-site tests that include daily bacteriological analysis, an examination of basic physical and chemical parameters — total dissolved solids, pH, turbidity, color and conductivity — that may have an impact on the taste of the water. The licensee's plant and facilities are monitored by regular surveillance via surprise inspections and testing of samples drawn both from the factory and the market.

4.2.5. Standards followed

The Bureau of Indian Standards has provided standards for different physical and chemical parameters for drinking water in IS 10500:1991, packaged drinking water (other than natural mineral water) in IS 14543:1998, and for natural mineral water in IS 13428:1998. According to these standards for packaged drinking water and packaged natural mineral water specification, individual pesticide residues are covered under the relevant rule of the Prevention of Food Adulteration Act, 1954, according to which it should **be below detectable limits** when tested in accordance with the "relevant methods". These "relevant methods" specify GC with ECD detector and packed column as the instruments for testing individual pesticides. Under these BIS norms, the maximum residue limit of individual pesticides as also that of total pesticide residue have not been quantified.

On the other hand the USEPA recommends the use of GC-ECD with capillary column for multi pesticide residue analysis, which is obviously more sensitive. In Europe the standards as per EC Directive 80/778/EEC lays down quantified norms. Directive 80/778/EEC with its 62 parameters on the " quality of water intended for human consumption" is regulated at European level. Parameter 55 has set maximum admissible concentration for individual pesticides and related products in drinking water at 0.1 µg/l (0.0001mg/l) and at 0.5µg/l (0.0005 mg/l) for total pesticide residue. In the present work the laboratory used European norms, as they quantify the permissible limits of both individual pesticides and total pesticides, unlike the vague BIS standard "Below detectable limits".

4.2.6. Source of raw water

Most of the plants the laboratory researchers visited in and around Delhi used groundwater as their raw water source. The water was drawn out through borewells located inside the plants. On checking, researchers found that borewell depth could go up to 500 feet below the ground.

4.2.7 Manufacturing process

Mineral water production technology involves combination of chemical treatment and filtration technique Plants like Minscot, Volga, Bailley, Prime, Aquaplus and Bailley combine chemical and filtration treatments; Bisleri and Paras lay more emphasis on filteration techniques. Different companies use a range of purification methods: adding chlorine to kill micro-organisms; ultrafiltration to remove suspended impurities; passing water through an ozonation process to eliminate bacteria; and using filters, both mechanical and organic, to remove physical impurities.

Contamination with microorganisms is common to surface water and is an increasing concern as far as groundwater is concerned. Disinfection is the inactivation of pathogens in drinking water. Two common techniques are chemical disinfection and irradiation with UV light. The chemical disinfectants used in water treatment are chlorine, chloramine, ozone, and chlorine dioxide. Of the chemical disinfectants, free chlorine is used most commonly. Effective chlorination and ozonation depends upon the length of time chlorine and ozone remains active in water, which depends in turn upon factors like temperature. Ozone can break down complex organic molecules into smaller organic molecules that can be readily used by bacteria as a food source. Chlorination provides residual disinfection, but ozone provides residual disinfection for a limited time (ozone is a high strength oxygen that quickly reverts to oxygen and bottled water may be in distribution for several weeks; storage conditions, especially, temperature, adversely affects the quality). UV disinfection is used in small systems that treat groundwater. UV irradiation has been demonstrated to be effective against bacteria and viruses, microbiological contaminants most likely to be found in groundwater. Combined ozonation and UV light treatment is effective in oxidation of pesticide to non-toxic products but sometimes oxidation leads to formation of more toxic products e.g. oxidation of methyl parathion to methylparaxon, which is more toxic.

Membrane technology comprises micro filtration (MF), ultra filtration (UF), nano filtration (NF) and reverse osmosis membranes (RO).

Micro filtration (0.1 micron) removes most of the fine suspended solids in the water and almost all protozoa and bacteria but is not able to remove the dissolved part of the natural organic matter.

Ultra filtration has smaller pores than used in micro filtration, can remove finer particles from the water and is capable of removing viruses also.

Nano filtration uses membranes with even smaller holes and requires operating pressure to force water through the membrane. This results in higher operating cost. It is effective in removing insecticides and herbicides. Cost involved in the technology and the backwashing of the membrane can consume a significant portion of the water produced.

Reverse osmosis (RO) uses a membrane (0.001 micron) that is semi-permeable, allowing the fluid being purified to pass through it, while rejecting the contaminants behind. Reverse osmosis filters remove lead and other large minerals and organics, but not smaller minerals and organics (such as chlorine and chloroform). Reverse osmosis is capable of rejecting bacteria, salts, sugars, proteins, particles, dyes, and other constituents that have a molecular weight of greater than 150-250 Daltons. The larger the charge and larger the particle, the more likely it will be rejected.

Membranes can be distinguished by their nominal pore size or nominal molecular weight cut-off. The molecular weight cut-off is an estimate of the smallest size molecule that can be retained by the membrane. RO units remove microscopic parasites, but any defect in the membrane would allow these organisms into the ‘filtered water’. Size of the membrane may vary from company to company and effectiveness depends on the size of the membrane. Most RO technology uses a process known as cross flow to allow the membrane to continually clean itself. The RO process requires a driving force to push the fluid through the membrane, and the most common force is pressure from a pump.

Activated charcoal adsorption is also used by some manufacturers, and is an effective method for the removal of chlorine, organic chemicals and pesticides, but not fluoride, nitrate, lead or other heavy metals. Activated carbon is particles of carbon that have been treated to increase their surface area; this enhances their ability to adsorb a wide range of contaminants. Because activated charcoal removes chlorine, these filters can breed bacteria. To prevent this, carbon filters are often impregnated with silver, which kills bacteria. Silver is, however, toxic to humans, if the unit releases too much silver into the water. Efficiency of pesticide removal by charcoal adsorption fluctuates greatly and depends upon the type of carbon filters being used by the different companies, as also on factors like fouling factor (blinding from dirt, algae); flow rate (often slowed by solid materials); pH effectiveness (varies with pH); contact time (may be too short for absorption to occur); extreme temperatures may effect the effectiveness; Bacterial growth (carbon fosters algae and growth which blinds the carbon); and inefficient back flushing (without mechanical mixing back flushing is difficult). The effectiveness of the carbon filters depends on Iodine content. Different grades are available based upon the iodine content, higher is the grade more is the cost.

Powdered activated carbon filtration, granulated carbon filtration and reverse osmosis have been demonstrated to be effective water treatment processes for removal of organic chemicals including pesticides (primarily acetanilide herbicides), but specific removal data on pesticides are not available. The effectiveness of RO and NF in removal of pesticides is not absolute: it depends on the pressure applied; higher the pressure, the larger the driving force. The kind of RO membrane also effects the efficiency. However, membrane size and pressure applied for RO play a key role in removing impurities. Leakage through membrane, glue lines, seals in the pressure vessels are other possibilities of pesticides getting in treated water.

Technology used: Reverse osmosis and Granular Activated Charcoal is the recommended method for the removal of Pesticides which most of the plants follow.

Why we are getting pesticides in bottled water?

- Pesticide residues were detected in raw water samples (underground samples), which is the source of water for the various manufacturers.
- Treatment technology given to the raw water is not sufficient for the removal of pesticides.
- The entire portion of water is not subjected to reverse osmosis; a portion of water is subjected to reverse osmosis and mixed with pretreated water to maintain the mineral content as per IS specifications.

5. LITERATURE REVIEW

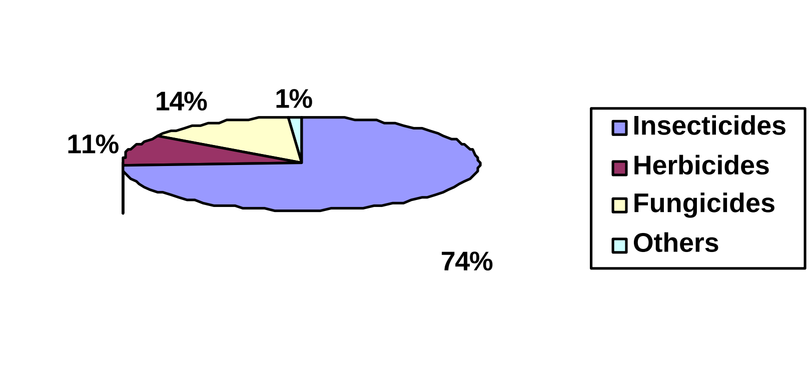
Pesticide is a general term for substances used to poison pests (weeds, insects, molds, rodents etc.) The pesticides most acutely dangerous to humans are insecticides and rodenticides. Not every pesticide is acutely toxic to humans or other non-target species (Aspelin AL, 1994). Synthetic pesticides have been popular with farmers, because of their simplicity in application, efficacy and economic returns. The consumption of pesticides in India has increased several hundred folds, from 154 MT in 1954 to 88,000 MT in 2000-2001. The industry has growth potential, as the use of agricultural pesticides is markedly is low at 540 gm/ha as against 3.7 kg/ha in USA and 2.7 kg/ha in Europe. (Source: Pesticide Information, Volume XXVII, No. 1, April- June 2002)

The Rs 3,500 crore Indian crop protection industry has large capacities at 162, 760 MT, which accounts for more than 10 percent of the global production, but translate merely into less than 2.5 per cent in value terms. There are over 180 pesticides registered in the country and 64 technical grade pesticides produced in the country.

In contrast to the global market where herbicides lead in market share at around 46 per cent, the Indian market accounts for a mere 11 per cent of herbicides **and is dominated by insecticides which account for 74 per cent shares.** As against insecticides there is a significantly low consumption of herbicides and weedicides, largely attributable to tropical climate favorable to insects rather than herbs and fungi.

In India, among different states maximum consumption of pesticides is in Uttar Pradesh (7459 MT.) followed by Punjab (6972 MT), Haryana (5025 MT.), Andhra Pradesh (4054 MT.), Gujarat (3,646 MT.) (See Table: 2)

Figure:1 Indian Agrochemical sales



(Source: Pesticide Information, Volume XXVII, No. 1, April- June 2002)

Table 2: Statewise consumption of pesticides (Metric Tonnes Technical grade) in 1999-2000

S. No.	State	1999-2000
1	Andhra Pradesh	4,054
2	Assam	260
3	Arunachal Pradesh	17
4	Bihar	832
5	Gujarat	3646
6	Goa	4
7	Haryana	5025
8	Himachal Pradesh	385
9	Jammu and Kashmir	26
10	Karnataka	2484
11	Kerala	1069
12	Madhya Pradesh	1528
13	Maharashtra	3614
14	Manipur	21
15	Meghalya	8
16	Mizoram	19

17	Nagaland	10
18	Orissa	998
19	Punab	6972
20	Rajasthan	2547
21	Sikkim	0.16
22	Tamil Nadu	1685
23	Tripura	17
24	Uttar Pradesh	7459
25	West Bengal	3370
26	Andaman and Nicobar	5
27	Chandigarh	4
28	Delhi	62
29	Dadar and Nagar Haveli	2
30	Daman and Diu	1
31	Lakshwadeep	1
32	Pondicherry	70
Total		46195.16

Source: Directorate of Plant Protection, Quarantine and storage, Faridabad

The indiscriminate use of pesticides has resulted in chronic toxicity, reduction in the biodiversity of the natural enemies of pests, outbreak of secondary pests, development of pest resistance and resurgence and disruption of non-target beneficial organisms. Notwithstanding the fact that overall consumption of pesticides in India as a whole is low (about a fraction of that used in the developed countries of the world), there is reportedly widespread contamination of water, soil and air with pesticide residues in agricultural areas where they are intensively used.

Pesticides enter surface and groundwater primarily as runoff from crops and are most prevalent in agricultural areas (Pimental D *et al*, 1991). There is a widespread pesticide pollution of freshwater bodies like rivers, lakes, and estuaries. Presently, only about 10 per cent of the wastewater generated from various sources is treated; the rest is discharged as it is into the waterbodies. Pollutants enter groundwater, rivers, and other water bodies unchecked. Such water, which ultimately ends up being used in households, is often highly contaminated with chemicals and disease-causing microbes. Agricultural run-off from farms contains pesticides. The water from the fields that drains into rivers carries fertilizers and pesticides (Barbash JE *et al*, 1996).

Groundwater is susceptible to contamination, as pesticides are mobile in the soil. These chemicals are also persistent in the soil and water. Without proper safeguards, pesticides can seriously pollute groundwater supplies. There are several factors which influence a pesticide's potential to contaminate water — the ability of the pesticide to dissolve in water (solubility), and environmental factors such as soil, weather, season, and distance of water sources from the place of pesticide spray. (Gustafson DI *et al*, 1993).

DDT residues in water, bottom sediments and certain non-target organisms from four different sites of the river Yamuna in Delhi were monitored from 1976 to 1978. The concentration of total DDT residues ranged from 0.04 µg/l to 3.42 µg/l in water, 0.007 to 5.63 mg/Kg in bottom sediments, 0.05 to 15.24 mg/kg in various invertebrates and 0.54 to 56.31 mg/kg in different fish. The total DDT concentration in water at Wazirabad upstream (where the Yamuna river remains cut off from all the drainages of the city) was 0.24 mg/l as compared to 0.558 mg/l at Wazirabad downstream, where the river receives water from Najafgarh drain. (Aggarwal HC *et al*, 1986). This clearly shows high amount of DDT being consumed within Delhi.

An Indo-Dutch study has shown alarming levels of pesticides in the Yamuna water supplies to Delhi. Organochlorines like aldrin, BHC, DDT, dieldrin were detected in the range of 0.001 - 1.064 µg/l (Agarwal A, 1997). Organochlorine residues were detected in the sediments of the river Ganga. Of the various organochlorines detected γ-HCH (0.002 - 0.014 µg/g), aldrin (0.0012 - 0.12 µg/g), dieldrin (0.002 - 0.014 µg/g), heptachlor (0.0014 - 0.008 µg/g) and heptachlor epoxide (0.002 - 0.018 µg/g) were more frequently present (Ahmad S et al, 1996).

Water samples from five lakes of Nainital (UP) used for drinking and domestic use showed the presence of DDT (6.054-31.336 µg/l) and HCH (3.121-8.656 µg/l), despite the fact that no insecticide was used in the vicinity of lakes for the vector control programme. (Dua K *et al*, 1998). This indicates the high mobility of DDT and HCH. BHC and DDT residues were also detected in the waters of Keoladeo National park and Bharatpur, Rajasthan in the range of 0.58 and 3.86 µg/l (Murlidharan, 2000).

A number of researchers have reported pesticides and heavy metals in drinking and groundwater in different parts of India. (Bouwer H, 1989; Dikshit TSS et al, 1990; Jani JP e al, 1991; Kumar S, 1995; Bansal OP et al, 2000; Ray PK, 1992). HCH and DDT were detected in different sources of water – wells, hand pumps and ponds — in Bhopal. Water samples of wells in Bhopal showed residues of total HCH (4640 µg/l) and total DDT (5794 µg/l) (Bouwer H, 1989). Drinking water samples from Ahmedabad showed total HCH (α β γ) was 23.90-2488.70 nanogram/l and total DDT (p,p-DDE, o,p'-DDT and p,p'-DDT) in the range of 10.90-314.90 nanogram/l respectively (Jani JP *et al*, 1991).

Organochlorine and organophosphorus pesticide residues were detected in groundwater samples from irrigation wells, domestic wells and canals used for irrigation and drinking purposes in Aligarh (Ray PK, 1992). Aldrin and dieldrin residues in soil, earthworms, water, fish and clams from different sites in Delhi were monitored. Concentration of aldrin and dieldrin was higher in earthworms than in soil. Concentration of dieldrin was higher in fish than the ambient water; concentration of aldrin in the ambient water was the same as that in fish and clams. The concentration of aldrin and dieldrin residues in water samples collected from different sites upstream and downstream sections of river Yamuna in Delhi ranged from 0.0005 - 0.05 µg/ml (upstream) and from 0.0001 - 0.1 µg/ml (downstream) respectively. (Nair A *et al*, 1991).

There are a few reports on the presence of organophosphorus insecticide residues in different rivers of India (Mohapatra SP *et al*, 1994; Agnihotri NP, 1994). Multiple residues of organophosphorus pesticides were monitored in Ganga riverwater and groundwater in a rural area in Farrukabad in Northern India during 1991-92 (Agnihotri N P *et al*, 1994).

6. MATERIALS AND METHODS

6.1. Sampling methodology

Bottled drinking water of top five brands – Bisleri (Aqua Minerals Ltd), Bailley (Parle Agro Ltd), Nestle (Nestle India Ltd), Aquafina (Pepsico India Holding Pvt Ltd), Kinley (Hindustan Coca Cola Beverage Pvt. Ltd) — and other less popular brands which were being sold in Delhi and nearby areas like Gurgaon and Meerut, were purchased randomly. (Details of the sample collected are given in ANNEXURE I.) Analysis was done at the Pollution Monitoring Laboratory for pesticides during the period July 2002 to December 2002. 2 bottles each of 17 different brands (34 samples) were analysed for twelve organochlorines and eight organophosphorus pesticides. The 12 organochlorines cover the wide spectrum of chlorinated pesticides. The 8 organophosphorus pesticides are the ones most commonly used in India.

Raw water samples from 6 locations from the different plants were also analysed. Row water sample were collected in clean plastic bottles rinsed with hexane and tightly capped. Water sample analysed immediately after collection. (Details of the raw water sample are given in ANNEXURE: II.) Extraction and analysis was done for 34 samples and 6 raw water samples by Gas Chromatograph (Thermoquest-Trace GC) with the electron-capture detector (ECD) following the protocol laid down by the USEPA Method 508.

6.2. Equipment

Gas Chromatograph used was Thermoquest-Trace GC with the ^{63}Ni selective Electron-Capture Detectors with advanced software (Chromcard-32 bit Ver 1.06 October

98) and capillary column, DB-5-J & W make (length 30m ID 0.25 mm and film thickness 0.25 µm. A 10-µl syringe from Hamilton Co. was used. Rotatory evaporator (Buchi type) was also employed.

6.3. Solvents

All the solvents used — methylene chloride, methyl- tertiary - butyl- ether (HPLC) grade — for the analysis were purchased from E-Merck.

6.4. Chemicals

All the chemicals (sodium chloride, sodium sulfate) were purchased from s. d. Fine Chem Ltd. The standards of organochlorine pesticides like aldrin, α, β, γ δ-HCH, DDD, DDE, DDT, heptachlor, dieldrin, α-, β-endosulfan and organophosphosphorus pesticides like methyl parathion, dimethoate, malathion, phosphamidon, profenofos, chlorpyrifos, parathion and diazinon chosen for study were obtained from RDH Laborchemikalien GmbH & Co., KG D-30918 Seelze and Sigma chemicals, USA.

6.5. Sample extraction and Clean up

Extraction: Water samples were shaken well and filtered through whatman filter paper no.1. pH of the samples were checked and it was found that pH of all the samples was neutral. After filtration, 1 litre water sample was taken in a 2 litre capacity separatory funnel and 20-30 ml of saturated sodium chloride solution was added. The water sample was partitioned with 100 ml of methylene chloride (thrice) by shaking the separatory funnel vigorously for 2-3 min and releasing the pressure intermittently. The layers were allowed to separate. The three extracts of methylene chloride layers were combined and passed through anhydrous sodium sulphate and concentrated to about 1-2 ml using rotary vacuum evaporator. Again 10 ml methylene chloride was added for adsorption chromatography

Clean up: Cleanup was done by column chromatography packed with activated silica gel 10g (2h at 130°C) packed between two layers of sodium sulphate (5g each) and the column was eluted with 150 ml methylene chloride. Eluent was collected and concentrated to dryness. Final samples were prepared in methyl tertiary butyl ether (HPLC grade) and analyzed by Gas Chromatograph.

6.6. Sample Analysis

2 µl of the sample was injected and analyzed for the presence of pesticides, by Gas Chromatograph (Thermoquest-Trace GC) with the ^{63}Ni selective electron-capture detector. This detector allows the detection of contaminants at trace level concentrations in the lower ppb range in the presence of a multitude of compounds extracted from the matrix to which the detector does not respond.

The capillary column used was DB-5 coated with 5% diphenyl and 95% dimethylpolysiloxane. The carrier gas and the makeup gas was nitrogen with a 0.4 ml/min and 60-ml/min-flow rate respectively employing the split less mode. The oven temperature was kept at 60°C to 300°C with a ramp of 4°C/min. The detector and injector were maintained at 320°C and 250°C, respectively. The samples were calibrated (retention time, area count) against standard mixture of known concentration of all twelve organochlorine and eight organophosphorous pesticides. Each peak was characterized by comparing relative retention time with those of standards. Identifications were confirmed by spiking with known standard and by performing thin layer chromatography of the pooled extract. Solvent systems used were 2% acetone in heptane and 10% chloroform in hexane. The spots corresponding to the position of standards were scraped, extracted and analysed by GLC.

The identifications were crosschecked with another GLC capillary column – DB-17- coated with 50% phenyl, 50% methyl polysiloxane (length 30m, ID 0.25 mm and film 0.25 µm).

6.7 Calculations

All calculations were done as described in USEPA method and the amount of residues in samples were obtained**.**

Recovery tests were carried out prior to the analysis of the samples by fortifying the water sample with standard solutions of organochlorine and organophosphorus pesticides to find the efficiency of the analytical techniques. Recovery was in the range of 80-90 per cent for organochlorines and 60-70 per cent for organophosphorus pesticides.

7. RESULTS AND DISCUSSION

7.1 Results of Raw Water samples tested for pesticides

Raw water samples collected from the 6 bottled water plants showed the frequent presence of HCH, DDT, malathion and chlorpyrifos. Some raw water samples also showed the presence of endosulfan, dieldrin, dimethoate and methyl parathion. (Results are given in ANNEXURE- III & IV)

7.1.1 Organochlorines

γ-HCH (lindane) was detected in all the raw water samples collected from different plants, with a minimum concentration of 0.0027 mg/l in the water sample from Minscot Plant (Gurgaon) and a maximum of 0.0057 mg/l detected in raw water collected from Bailley Plant.

α–endosulfan was detected only in one raw sample from Volga Plant, out of 6 raw water samples analysed. Concentration level was 0.0017 mg/l.

Heptachlor was detected in one raw water sample collected from Bisleri Plant (Shivaji Marg); its concentration level was 0.0005 mg/l.

DDT was detected in six raw water samples, with a minimum concentration of 0.001 mg/l detected in raw water from Burari (Aquaplus plant) and a maximum concentration of 0.0028 mg/l detected in raw water from Volga Plant.

DDD was detected in one sample from Bailley Plant and the concentration was 0.0008 mg/l. DDE, a metabolite of DDT, was detected in 5 out of 6 raw water samples analyzed, with a minimum concentration of 0.0005 mg/l and a maximum of 0.0017 mg/l.

7.1.2 Organophosphorus pesticides

Dimethoate was detected in 2 out of 6 raw water samples analysed. Minimum concentration was detected in raw water from Bailley, and maximum concentration was detected in the raw water sample from Volga: 0.1122 mg/l.

Methyl parathion was detected in 3 out of 6 raw water samples analysed. Minimum concentration of 0.0001mg/l was detected in raw water from Burari (Aquaplus), and maximum concentration in raw water sample from Volga: 0.0093 mg/l.

Chlorpyrifos was detected in 6 out of 6 raw water samples analysed. Minimum concentration of 0.0050 mg/l was detected in raw water from Gurgaon (Minscot plant), and maximum concentration detected in raw water sample from Aquaplus: 0.0220 mg/l.

Malathion was detected in 6 out of 6 raw water samples analysed. Minimum concentration of 0.0114 mg/l was detected in raw water from the Bailley plant, and maximum concentration detected in raw water sample from the Bisleri plant: 0.0649 mg/l.

Parathion was detected in 1 out of 6 of raw water samples analysed. Minimum concentration of 0.0064 mg/l was detected in raw water from the Volga plant.

The average concentration of total pesticides in raw water in terms of 12 organochlorines and 8 organophosphorus pesticides was 0.0757 mg/l

Table : 3 Total Pesticide Residues in raw water samples collected from the plants in Delhi: (July-December, 2002)

			Residues (mg/l)	
S. No.	Name	Total organochlorines	Total organophosphorus	Total Organochlorines +Organophosphorus
1.	Volga Plant-Inside Borewell	0.0119	0.1616	0.1735
2.	Bailley Plant- Inside Borwell	0.0103	0.0592	0.0695
3.	Paras Plant- Inside Borewell	0.0077	0.0195	0.0272
4.	Bisleri Plant- Inside Borewell	0.0069	0.0759	0.0828
5.	Minscot plant- Inside Borewell	0.0039	0.026	0.0299
6	Aquaplus Plant- Inside Borewell	0.0070	0.0641	0.0711
	Average Value	0.0080	0.0677	0.0757

Note:
1: Average of three replicates
2: ND- Not detected

7.2 Bottled Water samples

7.2.1 Organochlorines

Analysis of mineral water samples revealed that HCH was present in 32 out of 34 bottled water samples analysed. Among the various isomers of HCH, γ-isomer (lindane) was detected in all the samples except the foreign brand Evian. Incidentally, this is the most toxic isomer of HCH and is most commonly used in India. (Results in ANNEXURE V).

Minimum concentration of γ-HCH (0.0001 mg/l) was detected in Kinley (Batch No. 099) sample; maximum concentration (0.0045 mg/l) in Hello (Batch No. 377) sample, which is 45 times higher than that prescribed in Directive 80/778/EEC.

Hexachlorocyclohexane (HCH) is used against sucking and biting pest and as smoke for control of pests in grain sores. It is used as dust to control various soil pests such as flea beetles and mushroom flies. It is in the list of banned pesticides in India (with effect from April 1, 1997). HCH, previously called BHC (benzene hexachloride), is a mixture of eight isomers of which five are found in the crude product (α, β, γ, δ, ε Only the γ isomer or lindane has powerful insecticidal properties. It is very effective against a wide variety of insects, including domestic insects and mosquitoes. γ-HCH (lindane) appears in the list of pesticides for restricted use. Only γ isomer of HCH was detected in bottled water samples, which might be because γ-HCH is more resistant to biological and chemical degradation under aerobic conditions (El beit *et al*, 1981) and is most commonly used.

DDT was detected in 24 samples out of the 34 samples of bottled water samples analysed. Minimum concentration was detected in Minscot (Batch No: 5/182) i. e 0.0001 mg/l and highest concentration was detected in sample of Volga (Batch No.A-365): 0.0037 mg/l, 37 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC.

DDD was present in 1 out of the 34 samples analysed. Levels of DDD in 1 sample of Volga (Batch No. A-365) was 0.0003 mg/l, which is 3 times higher than the Directive 80/778/EEC limit.

DDE was present in 10 out of 34 samples analysed. Concentration ranged between 0.0004 mg/l (Aquaplus batch no-B-93) to 0.0.0077 mg/l in Bailley (Batch No. 2202). Use of DDT is banned in agriculture. However its restricted use is allowed in public health sector (10,000 MT per annum).

DDT was detected in most of the samples perhaps due to its persistent nature. Since DDT is known to undergo metabolic conversion and dehydrochlorination, presence of metabolites of DDT i.e DDD and DDE encountered in this study might be due to such metabolic processes.

Endosulfan is a broad-spectrum insecticide and acaricide. - endosulfan was detected in 3 out of 34 samples analysed. Maximum concentration of 0.0006 mg/l was detected in Hello-1 (batch No. 377), 6 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC.

Heptachlor (banned with effect from September 20, 1996), aldrin (banned with effect from September 20, 1996), diedrin (banned with effect from May, 1990) were absent in all samples. (Data related to the presence of different organochlorines in the packaged as well as natural mineral water is given in ANNEXURE V).

The findings of the laboratory corroborates various studies undertaken previously on drinking water and groundwater in different regions of India (Bouwer H, 1989; Dikshit TSS *et al*, 1990; Jani JP *et al*, 1991; Kumar S, 1995; Bansal OP et al, 2000; Ray PK, 1992; Dua K et al 1998). Most of the organochlorine pesticides are either banned in agriculture use or come under the list of restricted use like DDT and lindane. Residues of organochlorines were detected in most of the samples, as they are persistent in nature due to their slow decomposition rate, long half-life and high stability in the environment.

7.2.2 Organophosphorus pesticides

The bottled water samples were tested for the presence of eight organophosphorous pesticides — methyl parathion, dimethoate, malathion, phosphamidon, profenofos, chlorpyrifos, parathion and diazinon. The residues of these pesticides in different brands of natural and packaged mineral water are given in ANNEXURE VI.

Dimethoate is a systemic and contact insecticide and acaricide, effective against red spider mites and thrips on most agricultural and horticultural crops. Dimethoate was detected in one sample out of 34 analysed i.e in Aquafina (batch No. B-38). Concentration was 0.0013 mg/l, 13 times higher than the 0.0001mg/l limit for individual pesticide in Drinking water Directive 80/778/EEC.

Phosphamidon was detected in 2 out of 34 samples and maximum concentration of 0.0012 mg/l was detected in Kingfisher (Batch No. IB006), 12 times higher than the 0.0001mg/l limit for individual pesticide in Drinking water Directive 80/778/EEC.

Chlorpyrifos is a moderately persistent insecticide effective against mosquito and fly larvae, cabbage root fly, aphids. Chloropyrifos has become one of the most widely applied insecticides in homes restaurants against cockroaches, termites. It was detected in 28 out of 34 samples analysed. Chlorpyrifos concentation ranged from 0.0003 mg/L (Kinley - Batch No.0003) to a maximum of 0.0370 mg/l (No 1 No 1 McDowell- batch No. A) or 370 times higher than the 0.0001mg/l limit for individual pesticide in drinking water Directive 80/778/EEC.

Malathion was detected in 29 out of 34 samples and the levels ranged between 0.0004 mg/L (Aquafina: Batch No: B-39) to a maximum of 0.0400 mg/l (Bisleri Batch No. 0719), which is 400 times higher than the the 0.0001mg/l limit for individual pesticide in drinking water Directive 80/778/EEC. Malathion an important and widely used contact insecticide and acaricide for the control of aphids, red spider mites, leaf hoppers and thrips on a wide range of vegetable and other crops. It is also used to control insect vectors like mosquitoes. It is rapidly absorbed by practically all routes including the gastrointestinal tract, skin, mucous membranes, and lungs. Malathion requires conversion to malaoxon to become an active anticholinesterase agent. Most of the occupational evidence indicates a low chronic toxicity for malathion.

The organophosphorus pesticides are less persistent in water, soil, food and feed for animals than the organochorine pesticides; however they are relatively soluble in water and are highly toxic. They break down into nontoxic metabolites. There are a few reports on the concentration of organophosphorus insecticide residues in different rivers of the world (Albinos TA *et al* , 1986; Brunneto R *et al* , 1992) and drinking water (Mukherjee D *et al* , 1980; Raju GS *et al* ,1982). Few organophosphates have been detected in surface water or groundwater (Bansal OP *et al*, 2000; Ray PK, 1992).

7.2.3 Total Pesticides

Except one brand, Evian, pesticide residues (organochlorines and organophosphorus) were detected all different brands. The residues were from the range of below detectable limit in Evian to a maximum of 0.0521 mg/l (Aquaplus), which is 104 times higher than the EEC limit of 0.0005 mg/l for total pesticides. ANNEXURE IX gives the presence of total organochlorines and organophosphorus pesticides in the different brands.

Table: 4 Pesticide Residues in Bottled Water (mg/l)

Brands	Total Organochlorines	Total Organophosphorus	Total Organochlorines+ Organophosphorus
Evian	ND	ND	ND
Minscot	0.0016	0.0033	0.0049
Catch	0.0019	0.0009	0.0028
KwencheR	0.0033	0.0215	0.0248
Prime	0.0028	0.0038	0.0066
Hello	0.0078	0.0138	0.0216
Himalayan	0.0015	0.0000	0.0015
Volga	0.0061	0.0254	0.0315
Bailley	0.0084	0.0128	0.0212
No 1 McDowell	0.0047	0.0376	0.0422
Aquafina	0.0009	0.0027	0.0036
Paras	0.0043	0.0145	0.0188
Pure life	0.0036	0.0036	0.0072
Bisleri	0.0030	0.0365	0.0395
Aquaplus	0.0046	0.0476	0.0522
Kinley	0.0012	0.0061	0.0073
Kingfisher	0.0042	0.0207	0.0249

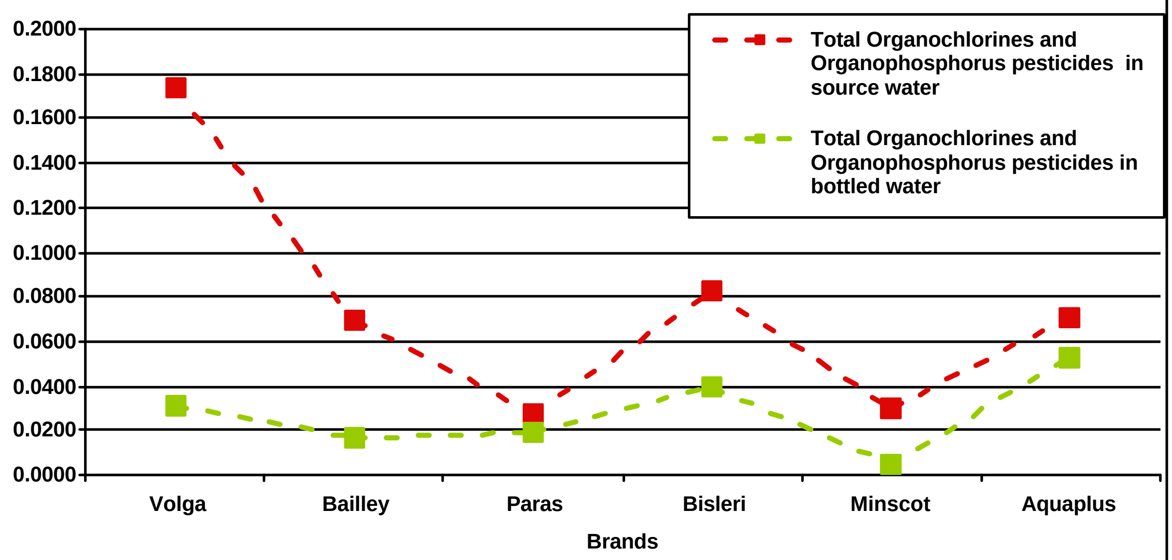
Average of 2 samples (three replicates of each)
ND: Not detected

7.3 Comparison between raw water and bottled water samples

The concentration of organochlorine and organophosphorus pesticide residues was higher in the raw water samples than detected in the bottled water samples manufactured at these plants, which suggests that the treatment given at various plants reduces the concentration of pesticides residues but does not completely remove them. Even the top brands — which claim to use treatment methods like purification filtration, activated carbon filtration, and demineralization and reverse osmosis — were found to contain residues of pesticides. (Results are given in ANNEXURE VII &VIII).

The interesting finding of this study is the close relationship between the levels of pesticides in the raw water collected from the plant and the level of the pesticides in the bottled water samples manufactured at these plants. In Delhi most of the bottled water manufacturers use borewell water as the source water, which was found contaminated with pesticide residues. A comparison between raw water and the finished product is given in Figure: 2

Figure: 2 Comparison of pesticide residues in raw water and bottled water samples.



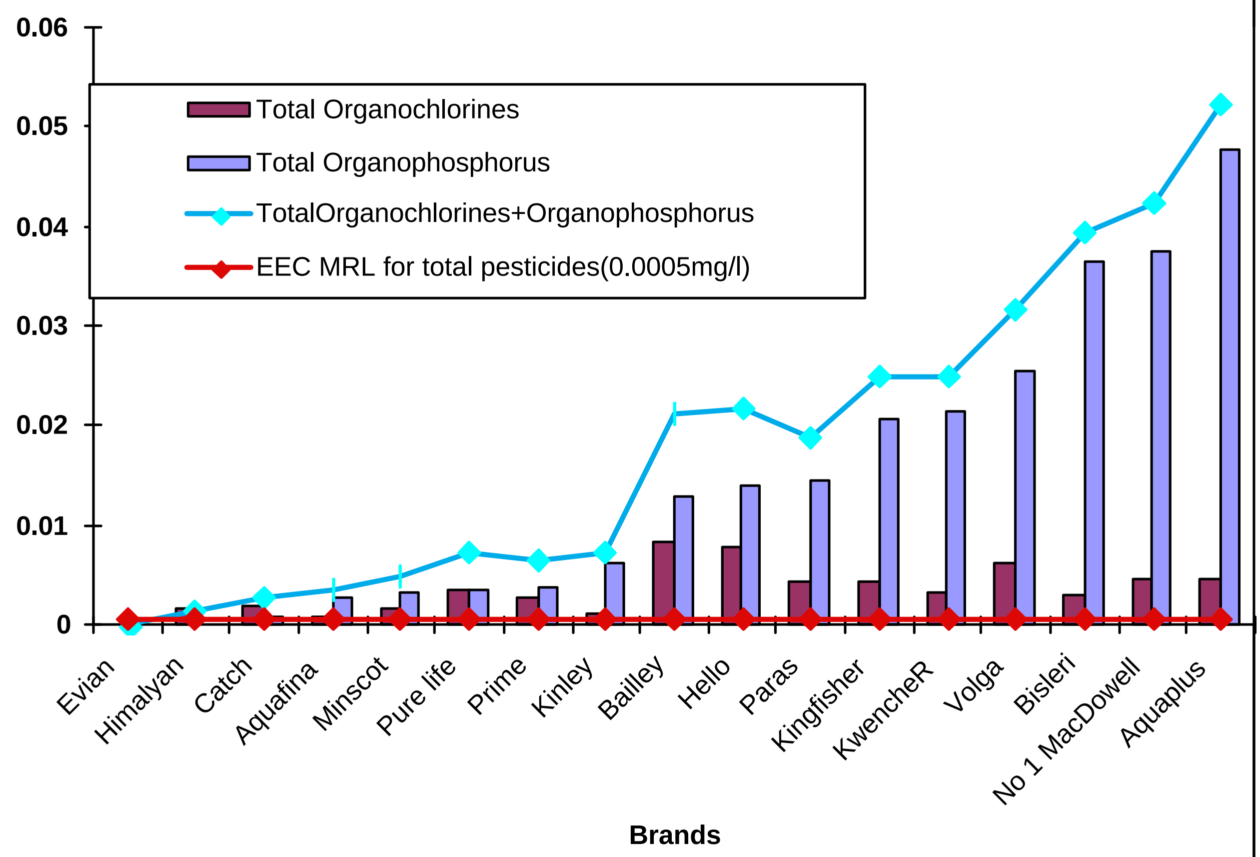
7.4 Correlation between consumption and contamination of pesticides

There seems to be a possible relationship between the amounts of pesticides found in the mineral water bottles with that of the amount of pesticides consumed in a state where the mineral water is bottled. Most of the plants of the bottled water analysed are located in Delhi, Uttar Pradesh Haryana (Gurgaon), and Himachal Pradesh, If we consider the amount of pesticides found in mineral water bottles, we see that pesticide consumption per unit area in Haryana (114.5 MT), Delhi (43.7 MT), UP (26.4 MT) and is quite high, the total amount of pesticides detected in mineral water bottled in these states is Haryana (0.015 mg/l), Uttar Pradesh (0.020 mg/l and Delhi (0.039 mg/l) was high. In contrast, in Himachal Pradesh (4.9 MT), where the pesticide consumption per unit area is very low, the total amount of pesticides in the mineral water bottled in HP (0.003 mg/l) is lowest. This gives a possible hint that the mineral water bottled is high pesticide consuming states are likely to contain more pesticides and vice-versa. However, this relationship has not considered the treatment efficiency of the various companies.

7.5 Rating of different brands

On the basis of the results, different brands can be rated in terms of total organochlorine and organophosphorus pesticide residues detected, as shown in Figure 3.

Figure: 3 Comparison of total organochlorines, total organophosphorus, and total organophosphorus pesticides in bottled water samples.



7.6 Information on the label of the bottle

BIS directives IS 14543:1998 and IS 13428:1998 lay down the information that ought to be provided by the manufacturer on the label on each bottle. The following particulars should be marked legibly and indelibly on the label of the bottle /container:

7.6.1 For Packaged Drinking Water

Name of the product (that is, packaged drinking water)

Name and address of the processor; Brand name, Batch or Code No., Date of processing / packing, Treatment of disinfection, Best for consumption upto or within a timeframe from the date of process or packing; Net Volume; Direction for storage; Any other marking required under the Standards of Weights and Measure (packaged commodities), Rules, 1977, and the Prevention of Food Adulteration Act, 1954 and the rules framed there under.

7.6.2 For Packaged Natural Mineral Water

Name of the product (packaged natural mineral water), Name and address of the processor; supplementary designation if necessary; Brand name, Batch or Code No., Date of processing / packing, Treatment of disinfection, Best for consumption upto or within from the date of process or packing: Net Volume: **Location and name of the source of natural mineral water**; Direction for storage: Any other marking required under the Standards of Weights and Measure Rules, 1977, and the Prevention of Food Adulteration Act, 1954 and the rules framed there under.

Most of the manufactures have named the place where the packaged mineral water is processed. Source of water is mentioned in natural mineral water but not in packaged drinking water. Catch, Himalayan, Evian mentioned the source.

Most of the brands have mentioned on the label whether it is packaged drinking water or packaged natural mineral water except No 1 McDowell.

BIS certification marking was present on all the brands except Kingfisher, Welcome, Pure Life and No 1 McDowell. Batch or code Number and date of processing were given on all the brands.

Most of the brands mention ozonization and UV treatment for disinfection on the label. Some also mention reverse osmosis.

No 1 McDowell and Pure Life, which fall under packaged drinking water, have not mentioned any treatment on the label.

Information related to time within which consumption is to be done and Net volume was mentioned on all the brands.

Direction for storage was given on all the brands except Bisleri, Volga, Kingfisher, Prime and Minscot.

Additional information like composition and mineral content was missing in most cases except Pure Life and Himalayan.

8. HEALTH IMPACTS OF PESTICIDES RESIDUES IN WATER

The four most frequently found pesticides found in the finished water are DDT, lindane (γ- isomer of HCH; most toxic of all the isomers of HCH), Malathion (least toxic) and Chlorpyrifos. Out of the four pesticides detected DDT, lindane and Chloripyrifos are included in the II moderately hazardous category of pesticides (Oral LD $_{50}$ rat 50-500 mg/Kg per body weight), and Malathion falls in the II slightly hazardous category (Oral LD $_{50}$ rat >500 mg/Kg per body weight) as classified by WHO (Table 18 a and 18 b). Multiple residues of this pesticide in drinking water might have chronic effects due to continuous exposure to levels above MRL in drinking water.

Among the different classes of pesticides, organochlorine pesticides are an important class due to their slow decomposition rate, long half-life and high stability in the environment. They are persistent in the environment and accumulate in the upper trophic levels of food chains (Raju GS *et al,* 1982; Kocan RM and Landolt ML, 1989; Gallo M Aand Lawryk NJ, 1991). Mild cases of poisoning are characterized by headache, dizziness, gastrointestinal disturbances, numbness and weakness of the extremities, apprehension and hyperirritability. When absorbed into the body, chlorinated hydrocarbons are not metabolized rapidly and are stored in the fat. Based on these and other facts, limits in drinking water have been calculated primarily on the basis of the extrapolated intake that would cause minimal toxic effects in mammals (Kidd H and James DR, 1991).

Organophosphorus pesticides are all derivatives of phosphoric acid. They contain phosphorous, carbon, hydrogen, oxygen and frequently sulphur. This group is less persistent in soil, food and feed for animals than the organochorine pesticides. They break down into nontoxic metabolites. With a few notable exceptions, members of this group are highly toxic and all act as cholinesterase inhibitors. Cholinesterase is an enzyme in the human body that is essential to the normal functioning of the nervous system. Inhibition of the activity of the cholinesterase enzyme prevents neural signals from being transmitted from the brain to various parts of the body. Symptoms of this inhibition include excess salivation, difficulty in breathing, blurred vision, cramps, nausea and vomiting, rapid or slow heart rate, headache, weakness and giddiness. The organophosphorous pesticides affect and damage the nervous system and can cause cancer. They can cause reproductive and endocrinal damage also.

Pesticides can be absorbed in the human body through the skin and lungs as well as by drinking water. Adverse health effects are not expected from consuming water with pesticides below the maximum residue limits. Potential health effects in people consuming pesticides above the maximum residue limits depend upon the kind and amount of pesticide, how long the person has been consuming that water, and the person's overall health.

In setting drinking water guidelines, the Acceptable daily intake (ADI) for a pesticide is calculated by dividing the NOEL (No observed effect level of uncertainty) in the experimental data. If valid experimental results are available from studies on prolonged ingestions by humans, for example, a minimum safety factor of 10 might be chosen. This could increase to as much as several thousand if human data were lacking and laboratory data were inconclusive. Most commonly, long-term animal feeding data are available and a safety factor of 100 is used. This is based on the assumption that humans are roughly 10 times more sensitive to toxic substances than laboratory animals and that the susceptibility between different individuals can vary another 10-fold. The resulting ADI represents an estimate of the amount of the pesticide that a typical person can consume daily for a lifetime with no adverse effects.

For Aldicarb, currently accepted NOEL is 0.1 mg/kg/day, and a safety factor of 100 is used, resulting an ADI of 0.001 mg/kg/day. Method of conversion from an ADI to a drinking water guideline varies from one agency to another. In New York State the 7 ppb guideline for aldicarb is derived from

NOEL (0.1mg/kg/day= 7mg/70 kg person/day

ADI= (NOEL/safety factor of 100)

= 7/100= 0.07mg/person/day

20 % of daily intake in drinking water 0.07 x 0.2 = 0.014 mg/person/day

Average intake of 2 litres water per day = 0.014 /2= 0.007 mg/l

Drinking water guideline 0.007 mg/l= 7 g/l (7ppb)

Other estimates used are: average weight of a person, amount of water consumed per day, percentage of daily intake of pesticide that would be consumed in drinking water. For non cancer-causing toxic substances, scientists use "acceptable daily intake" to estimate risk. It includes a margin of safety. For a cancer-causing substance, no safe level has been set. Toxicity is estimated by calculating a risk estimate, or the concentration of a substance that presents the least acceptable risk. In the case of cancer-causing toxins, regulations are based on a level of risk that is acceptable, not a safe amount or concentration of a substance (Hayes, WJ Jr. 1982; Kim, N.K. and Stone, 1981; National Research Council. (1983). EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children. Pesticides affect all humans, some more than others. For example, pregnant women and children are the most vulnerable. Even people that appear healthy pass on the toxic chemicals to their offspring. Children can become exposed in uterus and through breast-feeding at critical stages in their development. In fact, most people receive up to 12 per cent of their lifetime dose of toxic chemicals in the first year of life. Young children are more sensitive to the effects of toxic chemicals because they eat and drink more per body weight and have faster metabolisms than adults. In addition, children do not have fully developed immune systems to help them fight off the effects of these toxins. (Woodruff *et al*, 1990; Nancy M. Trautmann *et al* , 1984)

Studies of the health effects of pesticides on humans focus on two aspects, the acute toxicity, or immediate effects resulting from short-term exposure, and the chronic toxicity, or effects resulting from more-prolonged exposures.

8.1 Toxic Effects

8.1.1 Acute effects

The short-term toxicity of a chemical, manifested over a period of hours or days, is referred to as its acute toxicity. Acute toxicity, typically, is expressed as the concentration required killing 50 per cent of a population of test animals such as laboratory rats either through ingestion or through contact with the skin. These lethal concentrations can vary greatly from one pesticide to another. Parathion, for example, is considered to be highly toxic because the oral lethal dose is less than 4 milligram per kilogram (mg/kg) of body weight, compared with 1200 mg/kg for malathion, or 5,000 mg/kg for methoxychlor.

The levels of contaminants in drinking water are seldom high enough to cause acute (immediate) health effects. Examples of acute health effects are nausea, lung irritation, skin rash, vomiting, dizziness, and even death. Organophosphorus pesticides effect the central nervous system; acetylcholine accumulation results in anxiety, headache, confusion, convulsions, ataxia depression of respiration and circulation, slurred speech and tremor (Ecobichon D, 1994; Sherman JD, 1995).

8.1.2 Chronic effects

Contaminants are more likely to cause chronic health effects, that occur long after repeated exposure to small amounts of a chemical. Examples of chronic health effects include cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system, and birth defects. Evidence relating chronic health effects to specific drinking water contaminants is limited. In the absence of exact scientific information, adverse effects of chemicals in drinking water is predicted using human data from clinical reports and epidemiological studies, and laboratory animal studies.

On the basis of their chronic toxic effects, organic chemicals are grouped into the following three major classes: carcinogens, mutagens, and teratogens.

Any chemical that causes cancer in either a direct or an indirect form is called a carcinogen. Pesticides heptachlor, aldrin and dieldrin, are known to produce cancer in animals. Pesticides like DDT, HCH, dieldrin, etc, enter our bodies through the food we eat, the water we drink, and the air we breathe. Fish and other animals we consume in our diets are also exposed to these toxins the same way. These chemicals don't degrade and are stored in our fat tissues. Most of the toxic chemicals found in our water supply are fat soluble, which means they remain in a person's body for long periods of time. The incidence of breast cancer in women is increasing and *in vivo* and *in vitro* studies have shown that organochlorines promote mammary cancer (Joachim P *et al*, 2001).

All isomers of HCH are stored in fats; the gamma isomer of HCH (lindane), which was also found in bottled water samples analysed, is stored at much larger rates than the other isomers, which are more readily metabolized and eliminated. Lindane affects the central nervous system, liver, kidney pancreas, testes and nasal mucous membrane. Scientific studies have established a link between exposure to lindane and the immune system. Lindane is a known potent carcinogen. Rats exposed to gamma HCH showed evidence of liver cancer (ATSDR, 1989). Lindane was found to be estrogenic to female rats and mice, and also caused the testes of male rats to become atrophied. Seminiferous tubules and Leydig cells (important for production of sperms) were completely degenerated at dozes of 8 mg/Kg/day over a 10-day period (Gallo MA and Lawryk NJ, 1991).

DDT produces serious functional and morphologic changes in every organ of the body, however among its most disturbing and debilitating manifestations are those of the nervous system (Biden- Steele K and Stuckey RE, 1946).

Lifetime treatment of mice with DDT induced liver tumours in a doze related manner and the tumors included overtly metastasizing hepatoblastomas (Hoyer AP *et al*., 1998). Main metabolites of DDT (pp’ DDE and pp’ DDD) are probable carcinogens. Exposure to DDE resulted in high incidence of liver tumors in both male and female mice. The combined exposure to DDE and DDD resulted in a marked increase and early appearance of liver tumors in both sexes (Turosov VS *et al* ; 1973)

Worst is the impact of a cocktail of pesticides. There are mixture effects even when each mixture component is present at concentrations that individually produces insignificant effects.

Mixture of four organochlorines (op' DDT, pp' DDE, β-BHC and pp' DDT) acted together to produce proliferative effects in MCF-7 human breast cancer cells and the combined effect was additive (Gertrudis C *et al* 2001). A study suggests that exposure to a mixture of DDT, HCH and endosulfan and decreased fertility in males, an increase in birth defects and in neonatal deaths (Rupa DS, 1991)

Detoxification processes both in humans and animals involve conversion of DDT to less toxic acetate; little is known about variations from person to person in these detoxification mechanisms, and even less about intermediate metabolism concerned. Regardless of detoxification mechanisms, DDT is stored cumulatively in body fat and excretion is extremely slow even after intake ceases (Smith MI, 1946).

Malathion and parathion, incorporated through epithelium of skin, mouth and respiratory tract, are activated in the liver by enzymatic processes, producing malaoxon and paraoxon. Malathion and parathion are acetyl cholineesterase inhibitors and are responsible for hydrolysis of body choline esters, including acetylcholine (Ach) at cholinergic synapses (Silman I, and Futerman A., 1987) Malathion and parathion induced changes in the epithelium of rat mammary glands, influencing the process of carcinogenesis; such alterations occur at the level of nervous system by increasing the cholinergic stimulation (Vladimir T *et al* , 2002). In contrast to potent carcinogens, which induce mammary carcinomas in 100 per cent of intact females, parathion and malathion induced 14.3 and 24.3 per cent of mammary carcinomas. Type of tumors induced had papillary adenmatous patterns and ductal carcinomas with cribiform pattern (Willings SR *et al* , 1975).

Malathion has been reported to induce a slight increse in the incidence of chromosomal aberrations in bone marrow cells of rats exposed *in vivo*. (Kawachi T *et al*, 1980). Malathion caused a significant increase in sister chromatid exchange in human foetal lung fibroplasts after a single doze of 40 µg/l or a double doze of 20 µg/l (Nicholas AH *et al* , 1979).

A chemical capable of producing an inheritable change in the genetic material is called a mutagen. Any chemical that acts during pregnancy to produce a physical or functional defect in the developing offspring is known as a teratogen.

Chlorpyrifos is moderately toxic to humans. The oral LD 50 for chlorpyrifos in rats is 95-270 mg/kg (Kidd H and James DR, 1991). Chlorpyrifos is a suspected neuroteratogen. The effects of chlorpyrifos and its major metabolite chlorpyrifos oxon have been studied in two *in vitro* models, neuronotypic and gliotypic C6 cells. Chlorpyrifos inhibited DNA synthesis in both cell lines, but had greater effect on gliotypic cells. Chlopyrifos oxon, the active metabolite that inhibits cholinesterase, also decreased DNA synthesis in PC-12 and C-6 cells with a preferential effect on the latter. Diazinon also inhibits DNA synthesis with preference towards C-6 cells but is less effective than chlorpyrifos (Qiao D *et al* , 2001).

Chlorpyrifos in rats showed depression of cholinesterase enzyme (Gallo MA and Lawryk NJ, 1991).

Methyl-parathion is rapidly absorbed into the bloodstream through all normal routes of exposure. In water, methyl-parathion is subject to photolysis, with a half-life of 8 days during the summer and 38 days in winter. Following administration of a single oral dose, the highest concentration of methyl-parathion in body tissues occurred within 1 to 2 hours. Methyl-parathion does not accumulate in the body, and is almost completely excreted by the kidneys (urine) within 24 hours as phenolic metabolites. Methyl-parathion primarily affects the nervous system. Symptoms of acute exposure include the following: numbness, tingling sensations, in co-ordination, headache, dizziness, tremor, nausea, abdominal cramps, sweating, blurred vision, difficulty breathing or respiratory depression, and slow heartbeat. Very high doses may result in unconsciousness, incontinence, and convulsions or fatality. Persons with respiratory ailments, recent exposure to cholinesterase inhibitors, cholinesterase impairment, or liver malfunction is at increased risk from exposure to methyl parathion (Kaiser G and Tolg G, 1980).

Dimethoate is a moderately toxic compound and falls in EPA toxicity class II. Mammals rapidly metabolise dimethoate. Amongst several mammalian species tested, dimethoate appears to be less toxic to those animals with higher liver-to-body weight ratios and with the highest rate of dimethoate metabolism. However repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure, including the delayed symptoms (Forstener U, 1980).

Insecticides reported to have reproductive and endocrine-disrupting effects are: γ-HCH, lindane, carbaryl, malathion chlordane, methomyl, dicofol, methoxychlor, dieldrin, mirex, DDT, oxychlordane, endosulfan, parathion heptachlor, synthetic pyrethroids and toxaphene. In endocrine disruption, even low levels of pesticides can either imitate or block hormones like oestrogen, testosterone and thyroid hormone, which are extremely powerful chemicals normally present in the body in very tiny quantities. Possible effects of endocrine disrupters include infertility, endometriosis, breast cancer, low sperm count, testicular cancer, prostate enlargement, altered fetal and child development learning disorders. ***Other effects:*** Besides the above mentioned health effects there are other effects which include: arteriosclerosis; various forms of heart diseases; hypertension; emphysema; bronchitis; kidney and liver dysfunction; and diabetes. There is some evidence, which links organic chemicals to metabolic disorders that stimulate abnormal production of enzymes (Rao PSC *et al* 1987; Curtis KM *et al*, 1999).

9. CONCLUSIONS

Bottled Water has become a necessity in people's lives due to the poor quality of municipal water supply. However, from the results obtained from the study, we can conclude that:

Pesticide residues were detected in all the brands.

- According to Indian Standard for packaged drinking water — IS 14543:1998 — and natural mineral water — IS: 13428:1998 — pesticide residues covered under the relevant rule of the Prevention of Food Adulteration Act, 1954 should be "below detectable limits" when tested in accordance with the relevant methods. However, out of 5 top brands and other less popular brands tested for 12 organochlorine pesticides and 8 organophosphorus pesticides, most of the bottled water samples were contaminated with pesticide residues. The levels, however, were lower than the raw water. Among the 12 organochlorines tested in different brands of bottled water samples, HCH and DDT were commonly present
- HCH was detected in 91 per cent of mineral water samples, in 32 samples out of 34 analysed. The highest concentration of γ-HCH (0.0045 mg/l was detected in Hello (Batch No. 377) sample: 45 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC
- DDT was detected in 70.6 per cent of the samples analysed for pesticide residues. The highest concentration was detected in a sample of Volga (Batch no. 365), 37 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC
- Metabolites of DDT (DDE and DDD) were also detected in the bottled water samples analysed
- Among the 8 organophosphorus pesticides, malathion and chlorpyrifos were commonly present in different brands analysed
- Dimethoate was detected in only one sample out of 34, in Aquafina batch no. 38. Its concentration was 0.0013 mg/l, 13 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC
- Phosphamidon was detected in 6 per cent of the samples analysed. Maximum concentration of 0.0012 mg/l was detected in Kingfisher (Batch No. IB 006), which is 12 times higher than the Directive 80/778/EEC limit for individual pesticides
- Chlorpyrifos was detected in 82.4 per cent of the samples analysed. The highest concentration were in No 1 McDowell –1 and Volga (batch no. A): 0.037 mg/l, which is 370 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC

- Malathion was detected in 85.3 per cent of the samples. The highest concentration detected was 0.0400 mg/l in Bisleri (Batch No. 0719); this is 400 times higher than the 0.0001mg/l limit for individual pesticide in Directive 80/778/EEC
- Only Evian (Foreign brand) from France was found to be free from organochlorines and organophosphorus pesticides.
- Total pesticides (organochlorines and organophosphorus) detected in 17 different brands were in the range of below detectable limit in Evian to a minimum of 0.0006 mg/l in Kinley-2 (B.No. 99) and a maximum of 0.0521 mg/l in Aquaplus, which is 104 times higher than the 0.0005mg/l limit for total pesticides in Directive 80/778/EEC.

Pesticide residues detected in raw water samples

Raw water sample collected from the plants or from nearby areas showed the presence of HCH, DDT, Malathion and chlorpyrifos frequently.

Correlation between raw water and bottled water samples

The concentration of organochlorine and organophosphorus pesticide residues was higher in the raw water samples than detected in the bottled water samples manufactured at these plants, which suggests that the treatment given at various plants reduces the concentration of pesticides residues but does not completely remove them. Even the top brands, which claim to use treatment methods like purification filtration, activated carbon filtration, and demineralization and reverse osmosis, were found to contain pesticides.

Correlation between consumption and contamination of pesticides.

There seems to be a possible relationship between the amount of pesticides found in the mineral water bottles with that of the amount of pesticides consumed in a state where the mineral water is bottled. Most of the plants of the bottled water analysed are located in Delhi, Uttar Pradesh Haryana (Gurgaon), and Himachal Pradesh, If we consider the amount of pesticides found in mineral water bottles, we see that pesticide consumption per unit area in Haryana (114.5 MT), Delhi (43.7 MT), UP (26.4 MT) and is quite high, the total amount of pesticides detected in mineral water bottled in these states is Haryana (0.015 mg/l), Uttar Pradesh (0.020 mg/l and Delhi (0.039 mg/l) was high. In contrast, in Himachal Pradesh(4.9 MT), where the pesticide consumption per unit area is very low, the total amount of pesticides in the mineral water bottled in HP (0.003 mg/l) is lowest. This gives a possible hint that the mineral water bottled in high pesticide consuming states are likely to contain more pesticides and vice-versa. However, this relationship has not considered the treatment efficiency of the various companies.

Rating of different brands

On the basis of the results, different brands can be rated in terms of total organochlorine and organophosphorus pesticides from least to most contaminated: Evian (Not detected) > Himalayan (0.0015 mg/l) > Catch (0.0028 mg/l) > Aquafina (0.0036 mg/l) > Minscot (0.0048 mg/l)> Prime (0.0066 mg/l)> Pure Life (0.0072 mg/l)>Kinley (0.0073 mg/l)>Paras (0.0188 mg/l) >Bailley (0.0212 mg/l)>Hello (0.0216 mg/l)> Kwencher (0.0248 mg/l)>Kingfisher (0.0249mg/l)> Volga (0.0315 mg/l) > Bisleri (0.0395 mg/l)> No 1 McDowell (0.0422 mg/l) > Aquaplus (0.0522mg/l).

Treatment not effective for removal of pesticides

Technology used: Reverse osmosis and Granular Activated Charcoal is the recommended method for the removal of pesticides, which most of the plants follow:

Why, then, are there pesticide residues in bottled water?

- Pesticide residues were detected in raw water samples (underground samples), which is the source of water for the various manufacturers.
- Residues of pesticides were detected even in the finished water samples of different brands of packaged drinking water, which means that treatment methods (like microfiltration, ultrafiltration, reverse osmosis) followed by various manufacturers are either not effective in complete removal of pesticides, or the treatment is given to a part of the source water and not the entire water.
- Possibly the entire portion of water is not subjected to reverse osmosis. A portion of water is subjected to reverse osmosis (RO treatment removes the dissolved solids) and might be mixed with pretreated water to maintain the mineral content the bottled water is mandated to contain. This might be the reason for pesticide residues in finished water.

Information on the label not readable

Information to consumers might be important, but was insufficient or not accessible enough (written in small characters) on bottle labels. In some cases the batch number, date of manufacture and date of expiry were not mentioned clearly.

Insufficient information on the label.

Labeling information on source, and composition and treatment used, were missing from most of the brands. The actual source of water used is not always made clear on the label.

No quality control

There seems to be little or no quality control, since pesticide residues were detected in most of the brands. The bottles are subjected to in-house test once a month for different physiochemical parameters. Testing for pesticides, heavy metals, selenium and radioactivity is required to be done at various commercial test houses such as FRAC and SRIIR once a year. However when different batches of each brand were tested, different levels of pesticide residues were detected.

REFERENCES

Agarwal A (1997) Homicide by Pesticides. State of Environment Series, No-4, pp 54

Agency for Toxic substances and disease Registry (ATSDR) (1989). Public Health Statement for Hexachlorocyclohexane. Atlanta, GA: US Department of Health and Human Services

Aggarwal HC (1986) DDT Residues in the river Jamuna in Delhi, India. *Water Air and Soil Pollution* **28**: 89-104

Agnihotri NP, Kumar M, Gajbhiye VT and Mohapatra SP (1994). Organochlorine insecticide residues in Ganga River water near Farrukhabad, India. *Environ Monitoring Assesment* **30**: 105-112.

Ahamad S, Ajmal M and Nomani AA (1996) Organochlorines and polycyclic aromatic hydrocarbons in the sediments of Ganges River (India). *Bull. Environ Contamn Toxicol.* **57**:794-802.

Aspelin AL (1994) Pesticides industry sales and usage, 1992 and 1993 market estimates: U.S. EPA, Office of Pesticides Programs, Biological and Economic Analysis Div., Economic Analysis Branch Report **733-K-94-001**: 33.

Bansal OP and Gupta R (2000) Groundwater Quality of Aligarh district of Uttar Pradesh. *Pesticide Research Journal* **12 (2):** 188-194.

Barbash JE and Resek EA (1996) Pesticides in Groundwater Volume 2 of the series Pesticides in the Hydrologic Environment. Ann Arbor Press, Inc. Chelsea, Mich. pp 425.

Belot L. (2000). “ L’eau en bouteille, bataille des geants de l’agroalimentaire”, in Le Monde.

Beuret C, Kohler D and Luthi T (2000) "Norwalk like virus sequences detected by reverse transcription-polymerase chain reaction in mineral waters imported into or bottled in Switzerland. *Journal of Food Protection* **63**: 1576-1582, Biden- Steele K and Stuckey RE (1946) “Poisoning by DDT Emulsion: Report of a fatal case”, *Lancet* **2**: 235-236

Bouwer H (1989) Agriculture and Ground water quality*. Civil Engg* **59**: 60-63.

Business Today (Sep-16, 2001), pp 50-54.

Curtis KM (1999) The effect of pesticide exposure on time to pregnancy*. Epidemiology* **10**(2): 112-117.

Dikshit TSS, Raizada RB, Kumar SN, Srivastava MK, Kulshreshta SK and Adbolia UN (1990). Residues of DDT and HCH in major sources of drinking water in Bhopal, India. *Bull Environ. Contamn Toxico* **45**: 389-393

Dua K, Kumari R, Johari RK, Ojha VP, Shukla RP and Sharma VP (1998) Organochlorine insecticide residues in water from five lakes of Nainital (UP), India. *Bull. Environ Contmn Toxicol.* **60**: 209-215.

Ecobichon D (1994) Organophosphate pesticides-neurological and respiratory toxicity. *In*: Pesticides and neurological Diseases (Ecobichon DJ, Joy RM, eds). Boca Raton, FLCRC Press pp 171-250.

El Beit IOD, Wheelock JV, Cotton DE (1981) Factors affecting soil residues of dieldrin, endosulfan, gamma HCH, dimethoate. *Ecotoxicol and Environ Saf* **5**:135-60.

Ferrier C (2001) Bottled Water Understanding a social phenomenon. A Report commissioned by WWF.

Forstener U (1980) “ Handbook of Environmental Chemistry” Springer, Berlin pp 58-107

Gallo M A and Lawryk NJ (1991) Organophosphorus pesticides In: *Handbook of Pesticide Toxicology*. Hayes WJ Jr. and Laws ER Jr., Eds. Academic Press, New York, NY, 5-3

Gertrudis C, Mario V, Arnaldo V, Viviana D, Isolde R, Nicolas H and Gloria C (2001). A rat mammary tumour model induced by the Organophosphorus pesticides Parathion and Malathion, possibly through Acetyl cholinesterase inhibition. *Env. Health Perspectives* Vol 109 No. 5: 211-214

Gustafson DI (1993) Pesticides in Drinking Water (Published by Van Nostrand Reinhold, New York, NY. pp 4)

Hayes WJ, Jr. (1982) Pesticides studied in man. Williams and Wilkins, Baltimore, Md.
Hoyer AP et al. (1998) Organochlorine exposure and risk of breast cancer. *Lancet*; **352**:1816-1820.

India Today Health {Bottled water: How safe?} Dec’ 22, 1997.

Jani JP, Raiyani CV, Mistry JS, Patel JS, Desai NM and Kashyap SK (1991) Residues of organ ochlorine pesticides and polycyclic aromatic hydrocarbons in drinking water of Ahemdabad city. *Bull Environ. Contamn Toxico* **47**: 381-85.

Joachim P, Martin S and Andres K (2001) Mixture of four organochlorines enhances human breast cancer cell proliferation. *Env. Health Perspectives* **109** (4): 391-97

Rahel J, (1998) " Bottled water enterprise in India" unpublished study 39 pages.

Kaiser Gand Tolg G (1980)" Handbook of Environmental Chemistry" Springer, Berlin pp 1-57

Kawachi T, Yahagi T, Kada T, Tazima Y, Ishadate M, Sasaki M and Sugiyama T. (1980) Cooperative program on short term assays for carcinogenecity in Japan. IARC Sci. Publi **27**:323

Kidd H and James DR (1991) Eds. The Agrochemicals Handbook, Third Edition. Royal Society of Chemistry Information Services, Cambridge, UK, (as updated) pp 5-14

Kim, N.K., and D.W. Stone (1981). Organic chemicals and drinking water. New York State Department of Health, Albany.

Kocan RM and Landolt ML (1989) *Mar Environ Res* **27**: 177-193

Kumar S, Singh KP and Gopal M (1995) Organochorine residues in Rural drinking water sources of northern and north eastern India. *J. Environ Sci. Health* **A 30**:1211-1222.

MalikPP (2002) Packaged drinking water standards. *Everything about Water* pg 70-72.

Mohapatra SP, Gajbhiye VT and Agnihotri NP (1994) Organophosporus insecticide residues in the Aquatic Environment of a rural area. *Pesticide Res. Journal* **6** (2): 157-160.

Mortenson SR, Chanda SM, Hooper MJ, Padilla S (1996) Maturational differences in Chlorpyrifos- oxonase activity may contribute to age related sensitivity to chlorpyrifos. *J. Biochem Toxicol:* 279-287

Mukherjee D, Roy BR, Chakraborty J and Ghosh BN (1980) Pesticide residues in human food in Calcutta. *Indian J Med Res* **72**: 577-82.

Murlidharan (2000) Organochlorine residues in the Waters of Keoladeo National Park. *Bull. Environ. Contam. Toxicol.* **65**: 35-41.

Nair A, Dureja P, Pillai MKK. (1991) Levels of aldrin and dieldrin in environmental samples from Delhi, India. *The Science of Total Environment*. **108**:255-259.

Nancy M. Trautmann, Keith S. Porter and Robert J. Wagenet (1984) *Pesticides: Health Effects in Drinking Water*. Center for Environmental Research and Dept. of Agronomy Cornell University

National Research Council (1983). Drinking water and health. National Academy Press, Washington, D.C. employees of the U.S. Environmental Protection Agency and U.S. Geological Survey. Health Effects of Drinking Water Contaminants.

Nicholas AHY, Vienne M and Van den Berghe H (1979) Induction of sister chromatid exchanges in cultural human cells by an organophosphorus insecticide : malathion. *Mutat Res,* **67**: 167

NRDC, USIRG and Clean Water action, Trouble on Tap: Arsenic, Radon and Trihalomethane in our drinking water (1995).

Olson E (1999) " Bottled Water: Pure drink or pure hype?" Natural Resource Defense Council.

Pimentel DL and McLaughlen (1991) Environmental and economic impacts of reducing U.S. agricultural pesticide use. In D.Pimentel and A.A. Hanson (Eds.) CRC Handbook of Pest Management in Agriculture. 2nd ed. vol I. CRC Press. Boca Raton, pp 679-718.

Qiao D, Seidler JFand Slokin TAA (2001) Developmental neurotoxicity of chlorpyrifos modeled in vitro: Comparative effects of metabolites and other cholinesterase inhibitors in DNA synthesis in PC-12 and C-6 cells. *Env. Health Perspectives* **109** (9): 909-913.

Raju GS, Visveswariah K, Galindo JMM, Khan A and Majumdar SK (1982) Insecticide pollution in potable water resources in rural areas and the related decontaminaton techniques. *Pesticides* **16**(8): 3-6

Rao PSC, Rao MP, and Anderson BS (1987) "Organic pollutants in groundwater 2 Risk assessment." Soil Sci. Fact Sheet SL 55, Institute of Food & Agric. Sci., Univ. of Florida, Gainesville, FL.

Ray PK (1992) Measurements on Ganga River Quality- heavy metals and pesticides. Project Report Industrial Toxicology Research Center, Lucknow, India.

Rupa DS, Reddy PP and Redii OS (1991) Reproductive performance in population exposed to pesticides in cotton fields in India. *Environment Research,* 1991, **55**: 123-128.

Sherman JD(1995) Organophosphate pesticides-neurological and respiratory toxicity. *Toxicol Ind Health* **11**: 33-39

Silman I Futerman A (1987) Modes of Attachment of Acetylcholine esterase to the surface membrane *Eur J. Biochemistry* **170**: 11-20

Smith MI (1946) Accidental Ingestion of DDT , with a note on its metabolism in Man", J.AM.A, **131**:519-520

Stewart, Judith C, Lemley, Ann T, Hogan, Sharon I. and Weismiller, Richard A (1989). *Health Effects of Drinking Water Contaminants.* Cornell University and the University of Maryland. Fact Sheet 2.

The Hindustan Times online Sunday

Turosov VS, Day NE, Tomatis L, Gati E, Charles RT (1973) Tumors in CFI mice exposed for six consecutive generations to DDT. *J. Natl. Cancer Inst* **51**: 983-997

US Environment Protection Agency (1995) Determination of chlorinated pesticides in water by Gas Chromatography with an Electron Capture Detector. National Exposure Research Laboratory , Office of Research and Development, U. S. Environment Protection Agency, Cincinnati, Ohio 45268

Vladimir T, Valery R and Lorenzo T (2002) Dichlorodiphenyl trichloroethane (DDT): Ubiquity, persistence and risks. *Env. Health Perspectives* **110** (2): 125-128.

Willings SR, Jensens HM, Marcum RG (1975) An Atlas of subgross pathology of human breast with special reference to possible precancerous lesions. *J Natl Cancer Inst.* **55:** 231-273

Woodruff, Sandra L (1990) *Drinking Water: Present Problems, Future Directions.* Nutrition Clinics. **5**(2):1-21.

ACKNOWLEDGEMENT

We are thankful to Ms. Sunita Narain, Director, and CSE for her invaluable support, guidance and encouragement in carrying out this study. Thanks are also due to Ms. Gita Kavarana, Funding Unit and Mr. Chandra Bhushan, Coordinator of GRP unit for their help and suggestions throughout the study.

Details of the bottled water samples collected for the analysis of pesticide residues (Period:July-December '2002) **ANNEXURE : I**

S.No.	Name	Date of collection	Date of analysis	Place of purchase	Name and address of the manufacturer as per label.	Date of manufacture as per label	Date of Expiry as per label	Company Batch No.as per label
1	Bisleri-1	23/7/02	4/9/02	Lodhi Road	Delhi Bisleri Co Ltd, 60 Shivaji Marg, New Delhi 15	19/7/02	Best before 6 months from the date of Packing	719
2	Bisleri-2	25/7/02	4/9/02	Mayur Vihar	Aqua Minerals Ltd A-57 & 46, Sector 8, Noida UP	30/6/02	Same as above.	29
3	Aquafina-1	25/7/02	4/9/02	Mayur Vihar	Varun Beverage Ltd, Dautana, Chatta, District Mathura Road 282401	4/6/02	Best before 9 months from manufacture.	B-38
4	Aquafina-2	30/7/02	4/9/02	Lodhi Road	Same as above	6/6/02	Same as above.	B-39
5	Kinley-1	25/7/02	4/9/02	Mayur Vihar	Moon Beverages Ltd. A-32, Site IV, Sahibabad Industrial Area, Sahibabad, District Gaziabad UP . On behalf of Hindustan Coca Cola Beverage Pvt Ltd , Enkay Towers, Udyog Vihar, Phase V Gurgaon Haryana 122106 Under the authority of Coca Cola Company, Coca Cola	21/6/02	Best before 6 months from packing.	92
6	Kinley-2	4/8/02	4/9/02	Gurgaon	Same as above	28/6/02	Same as above.	99
7	Mcdowell-1	12/8/02	4/9/02	Meerut	Trade mark owners Mckdowell &Co. Ltd 51, Richmond Road,Banglore-560025. Manufactured & Marketed by Sampann overseas (P)Ltd G-51, Jainpur Indl Area, Kanpur Dehat- 209311 (U.P)	May-02	Best before within 6 months from the date of manufacture.	A
8	Mcdowell-2	18/8/02	4/9/02	Meerut	Same as above	May-02	Same as above.	B
9	Paras-1	26/8/02	4/9/02	INA Market	Paras Aqua Minerals C-2, Phase-I, Okhla Indl Area, New Delhi	22/8/02	Best before 6 months	787
10	Paras-2	28/8/02	4/9/02	Railway Stn	Same as above	16/8/02	Same as above.	1608
11	Bailley-1	28/7/02	4/9/02	India Gate	Parle Agro Ltd, Mumbai WE Highway, Andheri (E), Mumbai:400099. By explicit trading and Marketing Pvt Ltd, A-7, Sector 22, Indl Area. Meerut Road, Gaziabad -201003	22/6/02	Best before 6 months from packing.	2202
12	Bailley-2	25/8/02	4/9/02	Munirka	Same as above	21/8/02	Same as above.	2102
13	Pure life-1	30/7/02	4/9/02	Defence Colony	Nestle India LtdM-5A, Connaught Circus New Delhi-110001 At Patti Kalyana Kiwana Road, Samalkha, 132101 District, Panipat Haryana	5/6/02	Within 6 months	INUOEPNS
14	Pure life-2	30/7/02	4/9/02	Khan Mkt	Same as above	4/6/02	Same as above.	INUOPANS
15	Volga-1	3/7/02	4/9/02	Meerut	Sai Durga Aqua Minerals (P) Ltd, G-6, Udyog Kunj, Dasna Industrial Area, Gaziabad-201302	Jul-02	Use within 6 months	A365
16	Volga-2	3/8/02	4/9/02	Gaziabad	Same as above	Jul-02	Same as above	A365
17	Kingfisher-1	17/8/02	4/9/02	Green Park	Iceberg Foods Ltd 44th Km Stone, Delhi - Rohtak Highway Village & P.O Rohad District Jhajjar, Haryana.	7/8/02	Best before 6 months from the date of manufacture.	IB003
18	Kingfisher-2	22/8/02	5/9/02	Green Park	Same as above	12/8/02	Same as above	IB006

								ANNEXURE : I
19	Prime-1	28/8/02	5/9/02	Noida	Beltek Canadian Water Ltd, A-16, Hoisery Complex Ph II Extension Noida-201305	Sept, 02	Best before 6 months from packing.	4
20	Prime-2	28/8/02	5/9/02	Noida	Same as above	Sept, 02	Same as above	5
21	Aquaplus-1	13/8/02	5/9/02	Railwayn Stn	Bharat Minerals Kh.No. 44/20 Salempur, Majra, Burari, Delhi.	18/7/02	Best before 6 months from manufacture.	B-93
22	Aquaplus-2	26/8/02	5/9/02	Railway Stn	Same as above	28/8/02	Same as above	B-122
23	Hello -1	3/9/02	5/9/02	Noida [1]	Hello Aqua Minerals Ltd, Sector –8, Noida UP	Aug-02	Feb-02	377
24	Hello -2	4/9/02	5/9/02	Noida [1]	Same as above	Aug-02	Feb-02	378
25	Kwencher-1	4/8/02	4/9/02	Gurgaon	Iceberg foods Ltd. 44 km, Delhi Rohtak Highway, Village and PO Rohtak, Dist. Jhajjar (Haryana)	8/5/02	Within 6 months from manufacture.	B-128
26	Kwencher-2	13/8/02	5/9/02	Railway Stn	Same as above	3/8/02	Same as above	A:KK0102
27	Minscot -1	30/8/02	5/9/02	Gurgaon	Denson Poly Products Ltd GP- 37, HSIADC, Sector 18, Gurgaon-122001.	Aug-02	Use within 6 months	8/185
28	Minscot-2	30/8/02	5/9/02	Gurgaon	Same as above	Aug-02	Same as above	5/182
29	Himalyan-1	4/8/02	5/9/02	Defence Colony	Mount Everest Mineral Water Ltd, Dhaula Kuan , Poanta Sahib District- Sirmour (HP)	14/4/2002	Best before 12 months from packing.	157Q
30	Himalyan-2	4/8/02	5/9/02	Khan Market	Same as above	May-02	Same as above.	187S
31	Catch-1	4/8/02	5/9/02	Gurgaon	DS Foods Ltd. Raison Kullu HP India Regd. Office- 77/22, Ansari Road, Darya Ganj, New Delhi- 110002	1/12/01	Best before 12 months from packed date	IOW058
32	Catch-2	21/12/02	21/12/02	Mathura Road	Same as above	20/12/02	Same as above	IOW053
33	Evian-1	30/7/02	4/9/02	Defence Colony	Bottled at Cachat Spring by S. A. Evianles Bains(France). Imported by Sansula Foods & Beverages Pvt. Ltd 95, Mittal Chambers, Nariman Point, Mumbai- 400021	Feb-02	Best before 24 months.	NA
34	Evian-2	30/7/02	4/9/02	Khan Mkt	Bottled at Cachat Spring by S. A. Evianles Bains(France). Imported by Radha Krishna Food Land (P) Ltd. Majiwadi Village Rd, Majiwadi , Thane, 400601	Mar-02	Same as above.	NA

Note: NA- Not Available

1. Available in bottles of 20 litres in market. A sample of 1 litre each was taken from 2 different 20 litre bottles with different batch numbers.
2. All the sealed samples were collected.

Details of the raw water samples collected from the plants in Delhi. **ANNEXURE II**

S. No.	Raw Water Source	Location of Sample collection	Date of Sample collection	Date of Analysis
1	Volga Plant- Inside (Borewell)	G-6, Udyog Kunj, Dasna Industrial Area, Gaziabad-201302	13/8/02	3/9/02
2	Bailley Plant- Inside (Borewell)	A-7 Sector 22 Industrial Area, Meerut Road, Gaziabad	13/8/02	3/9/02
3	Paras Plant- Inside (Borewell)	C-2, Phase I, Okhla Industrial Area, New Delhi.	22/8/02	3/9/02
4	Bisleri Plant- Inside (Borewell)	60 - Shivaji Marg, New Delhi-15	25/7/02	4/9/02
5	Minscot Plant- Inside (Borewell)	GP-37, HSIDC, Sector 18, Gurgaon-122001	30/8/02	4/9/02
6	Aquaplus Plant- Inside (Borewell)	Kh. No. 44/20, Salempur, Burari, Delhi.	28/8/02	4/9/02

ANNEXURE-III

Organochlorine pesticide residues in raw water samples collected from different plants

				Residues (mg/l)										
S. No.	**Name**	**α-HCH**	**β-HCH**	**γ-HCH**	**δ-HCH**	**α- Endosulfan**	**β-endosulfan**	**Heptachlor**	**Aldrin**	**Dieldrin**	**DDT**	**DDD**	**DDE**	**Total**
1.	Volga Plant-Inside Borewell	ND	ND	0.0055	ND	0.0017	ND	ND	ND	0.0019	0.0028	ND	ND	0.0119
2.	Bailley Plant- Inside Borwell	ND	ND	0.0057	ND	ND	ND	ND	ND	0.0006	0.0019	0.0008	0.0013	0.0103
3.	Paras Plant- Inside Borewell	ND	ND	0.0043	ND	ND	ND	ND	ND	ND	0.0017	ND	0.0017	0.0077
4.	Bisleri Plant- Inside Borewell	ND	ND	0.0041	ND	ND	ND	0.0005	ND	ND	0.0015	ND	0.0008	0.0069
5.	Minscot plant- Inside Borewell	ND	ND	0.0027	ND	ND	ND	ND	ND	ND	0.0012	ND	ND	0.0039
6	Aquaplus Plant - Inside Borewell	ND	ND	0.0055	ND	ND	ND	ND	ND	ND	0.0010	ND	0.0005	0.0070
	Average Value			0.0046		0.0017		0.0005		0.0012	0.0017	0.0008	0.0011	0.0080
	Number of samples in which pesticides identified	0	0	6	0	1	0	1	0	2	6	1	4	6
	Minimum residues			0.0027		0.0017		0.0005		0.0006	0.0010	0.0008	0.0005	0.0039
	Maximum residues			0.0057		0.0017		0.0005		0.0019	0.0028	0.0008	0.0017	0.0119

Note:

1: Average of triplicate

2: ND- Not detected

ANNEXURE:IV

Organophosphorus pesticide residues in raw water samples collected from different plants.

		Residues (mg/l)									
S. No.	**Name**	**Dimethoate**	**Phosphamidon**	**Methyl Parathion**	**Chlorpyrifos**	**Diazinon**	**Profenofos**	**Malathion**	**Parathion**	**Total**	**Total Organochlorines +Organophosphorus**
1.	Volga Plant- Inside Borewell	0.1122	ND	0.0093	0.0087	ND	ND	0.0250	0.0064	0.1616	0.1735
2.	Bailley Plant- Inside Borwell	0.0402	ND	0.0005	0.0071	ND	ND	0.0114	ND	0.0592	0.0695
3.	Paras Plant- Inside Borewell	ND	ND	ND	0.0060	ND	ND	0.0135	ND	0.0195	0.0272
4.	Bisleri Plant- Inside Borewell	ND	ND	ND	0.0110	ND	ND	0.0649	ND	0.0759	0.0828
5.	Minscot plant- Inside Borewell	ND	ND	ND	0.0050	ND	ND	0.0210	ND	0.026	0.0299
6	Aquaplus Plant - Inside Borewell	ND	ND	0.0001	0.0220	ND	ND	0.0420	ND	0.0641	0.0711
	Average Value	0.0762		0.0033	0.0100			0.0296	0.0064	0.0677	0.0757
	Number of samples in which pesticides identified	2	0	3	6	0	0	6	1	6	6
	Minimum residues	0.0402		0.0001	0.0050			0.0114	0.0064	0.0195	0.0272
	Maximum residues	0.1122		0.0093	0.0220			0.0649	0.0064	0.1616	0.1735

Note:

1: Average of triplicate

2: ND- Not detected

Organochlorine residues in bottled water samples collected from Delhi. **ANNEXURE : V**

				Residues (mg/l)											
S. No.	**Name/**	**Batch No.**	**α-HCH**	**β-HCH**	**γ-HCH**	**δ-HCH**	**α-endosulfan**	**β-endosulfan**	**Heptachlor**	**Aldrin**	**Dieldrin**	**DDT**	**DDD**	**DDE**	**Total**
1.	Bisleri-1	719	ND	ND	0.0030	ND	ND	ND	ND	ND	ND	0.0008	ND	0.0005	0.0043
2.	Bisleri-2	29	ND	ND	0.0014	ND	ND	ND	ND	ND	ND	0.0003	ND	ND	0.0017
3.	Aquafina-1	B-38	ND	ND	0.0010	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0010
4.	Aquafina-2	B-39	ND	ND	0.0007	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0007
5.	Kinley-1	92	ND	ND	0.0021	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0021
6.	Kinley-2	99	ND	ND	0.0001	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	0.0003
7.	Mckdowell-1	A	ND	ND	0.0043	ND	ND	ND	ND	ND	ND	0.0011	ND	ND	0.0054
8.	Mckdowell-2	B	ND	ND	0.0032	ND	ND	ND	ND	ND	ND	0.0007	ND	ND	0.0039
9.	Paras-1	787	ND	ND	0.0031	ND	ND	ND	ND	ND	ND	0.0010	ND	0.0005	0.0046
10.	Paras-2	1608	ND	ND	0.0040	ND	ND	ND	ND	ND	ND	0	ND	0	0.0040
11.	Bailley-1	2202	ND	ND	0.0023	ND	ND	ND	ND	ND	ND	0.0011	ND	0.0077	0.0111
12.	Bailley-2	2102	ND	ND	0.0034	ND	ND	ND	ND	ND	ND	0.0016	ND	0.0006	0.0056
13.	Pure life-1	INUOEPNS	ND	ND	0.0040	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0040
14.	Pure life-2	INUOPANS	ND	ND	0.0032	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0032
15.	Volga-1	A365	ND	ND	0.0029	ND	ND	0.0004	ND	ND	ND	0.0016	0.0003	0.0007	0.0059
16.	Volga-2	A365	ND	ND	0.0027	ND	ND	ND	ND	ND	ND	0.0037	ND	ND	0.0064
17.	Kingfisher-1	IB003	ND	ND	0.0033	ND	ND	ND	ND	ND	ND	0.0006	ND	ND	0.0039
18.	Kingfisher-2	IB006	ND	ND	0.0030	ND	ND	ND	ND	ND	ND	0.0010	ND	0.0005	0.0045
19.	Prime-1	4	ND	ND	0.0020	ND	ND	ND	ND	ND	ND	0.0012	ND	ND	0.0032
20.	Prime-2	5	ND	ND	0.0016	ND	ND	ND	ND	ND	ND	0.0008	ND	ND	0.0024
21.	Aquaplus-1	B-93	ND	ND	0.0040	ND	ND	ND	ND	ND	ND	0.0008	ND	0.0004	0.0052
22.	Aquaplus-2	B-122	ND	ND	0.0026	ND	ND	ND	ND	ND	ND	0.0009	ND	0.0005	0.0040
23.	Hello -1	377	ND	ND	0.0045	ND	ND	0.0006	ND	ND	ND	0.0016	ND	0.0012	0.0078
24.	Hello ---2	378	ND	ND	0.0042	ND	ND	0.0004	ND	ND	ND	0.0022	ND	0.0009	0.0077
25.	KwencheR-1	B-128	ND	ND	0.0029	ND	ND	ND	ND	ND	ND	0.0005	ND	ND	0.0034
26.	KwencheR-2	A:KK0102	ND	ND	0.0029	ND	ND	ND	ND	ND	ND	0.0003	ND	ND	0.0032
27.	Minscot -1	8/185	ND	ND	0.0015	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	0.0017
28.	Minscot-2	5/182	ND	ND	0.0013	ND	ND	ND	ND	ND	ND	0.0001	ND	ND	0.0014
29.	Himalyan-1	157Q	ND	ND	0.0020	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0020
30.	Himalyan-2	187S	ND	ND	0.0009	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0009
31.	Catch-1	IOW058	ND	ND	0.0015	ND	ND	ND	ND	ND	ND	0.0008	ND	ND	0.0023
32.	Catch-2	IOW053	ND	ND	0.0010	ND	ND	ND	ND	ND	ND	0.0005	ND	ND	0.0015
33.	Evian-1	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
34.	Evian-2	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Average				*0.0025*			*0.0004*				*0.0009*	*0.0003*	*0.0012*	*0.0037*
	Number of samples in which pesticides identified		*0*	*0*	*32*	*0*	*0*	*3*	*0*	*0*	*0*	*24*	*1*	*10*	*32*
	% of total samples in which pesticide residues identified		*0.0*	*0.0*	*94.1*	*0.0*	*0.0*	*8.8*	*0.0*	*0.0*	*0.0*	*70.6*	*2.94*	*29.4*	*94.1*
	Directive 80/778/EEC for Drinking water		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00003	0.00003	0.00003	0.0001	0.0001	0.0001	
	Number of samples meeting standards		34	34	2	34	34	31	34	34	34				
	Minimum Amount				0.0001			0.0004				0.0001	0.0003	0.0004	
	Maximum Amount				0.0045			0.0006				0.0037	0.0003	0.0077	
	Deviation of Maximum Amount (No. of times)				45			6				37	3	77	

Note: **1:Average of triplicate**

2: ND -Not detected

3: NA -Not Available

Organophosphorus pesticide residues in bottled water samples collected from Delhi. **ANNEXURE : VI**

			Residues (mg/L)								
S. No.	**Name/**	**Batch No.**	**Dimethoate**	**Phosphamidon**	**Methyl Parathion**	**Chlorpyrifos**	**Diazinon**	**Profenofos**	**Malathion**	**Parathion**	**Total**
1.	Bisleri-1	719	ND	ND	ND	0.0109	ND	ND	0.0400	ND	0.0509
2.	Bisleri-2	29	ND	ND	ND	0.0024	ND	ND	0.0196	ND	0.0220
3.	Aquafina-1	B-38	0.0013	ND	ND	0.0023	ND	ND	0.0008	ND	0.0044
4.	Aquafina-2	B-39	ND	ND	ND	0.0006	ND	ND	0.0004	ND	0.0010
5.	Kinley-1	92	ND	ND	ND	0.0109	ND	ND	0.0010	ND	0.0119
6.	Kinley-2	99	ND	ND	ND	0.0003	ND	ND	0	ND	0.0003
7.	Mckdowell-1	A	ND	ND	ND	0.0370	ND	ND	0.0126	ND	0.0496
8.	Mckdowell-2	B	ND	ND	ND	0.0180	ND	ND	0.0075	ND	0.0255
9.	Paras-1	787	ND	ND	ND	0.0022	ND	ND	0.0128	ND	0.0150
10.	Paras-2	1608	ND	ND	ND	0.0040	ND	ND	0.0099	ND	0.0139
11.	Bailley-1	2202	ND	ND	ND	0.0025	ND	ND	0.0073	ND	0.0098
12.	Bailley-2	2102	ND	ND	ND	0.0049	ND	ND	0.0109	ND	0.0158
13.	Pure life-1	INUOEPNS	ND	ND	ND	0.0028	ND	ND	0.0008	ND	0.0036
14.	Pure life-2	INUOPANS	ND	ND	ND	0.0018	ND	ND	0.0018	ND	0.0036
15.	Volga-1	A365	ND	ND	ND	0.0059	ND	ND	0.0147	ND	0.0206
16.	Volga-2	A365	ND	ND	ND	0.0064	ND	ND	0.0238	ND	0.0302
17.	Kingfisher-1	IB003	ND	0.0001	ND	0.0060	ND	ND	0.0189	ND	0.0250
18.	Kingfisher-2	IB006	ND	0.0012	ND	0.0020	ND	ND	0.0132	ND	0.0164
19.	Prime-1	4	ND	ND	ND	0.0032	ND	ND	0.0007	ND	0.0039
20.	Prime-2	5	ND	ND	ND	0.0018	ND	ND	0.0018	ND	0.0036
21.	Aquaplus-1	B-93	ND	ND	ND	0.0100	ND	ND	0.0368	ND	0.0468
22.	Aquaplus-2	B-122	ND	ND	ND	0.0092	ND	ND	0.0392	ND	0.0484
23.	Hello -1	377	ND	ND	ND	0.0040	ND	ND	0.0110	ND	0.0150
24.	Hello ---2	378	ND	ND	ND	0.0046	ND	ND	0.0080	ND	0.0126
25.	KwencheR-1	B-128	ND	ND	ND	0.0060	ND	ND	0.0147	ND	0.0207
26.	KwencheR-2	A:KK0102	ND	ND	ND	0.0045	ND	ND	0.0178	ND	0.0223
27.	Minscot -1	8/185	ND	ND	ND	0.0018	ND	ND	0.0012	ND	0.0030
28.	Minscot-2	5/182	ND	ND	ND	0.0020	ND	ND	0.0015	ND	0.0035
29.	Himalyan-1	157Q	ND	ND	ND	ND	ND	ND	ND	ND	ND
30.	Himalyan-2	187S	ND	ND	ND	ND	ND	ND	ND	ND	ND
31.	Catch-1	IOW058	ND	ND	ND	ND	ND	ND	0.0012	ND	0.0012
32.	Catch-2	IOW092	ND	ND	ND	ND	ND	ND	0.0005	ND	0.0005
33.	Evian-1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
34.	Evian-2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Average		*0.0013*	*0.0007*		*0.0060*			*0.0110*		*0.0167*
	Number of samples in which pesticides identified		*1*	*2*	*0*	*28*	*0*	*0*	*29*	*0*	*30*
	% of total samplesin which pesticides identified		*2.9*	*5.9*	*0.0*	*82.4*	*0.0*	*0.0*	*85.3*	*0.0*	*88.2*
2	**Directive 80/778/EEC for Drinking water**		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Number of samples meeting standards		33	32	34	6	34	34	5	34	4
	Minimum amount					0.0003			0.0004		0.0003
	Maximum Amount		0.0013	0.0012		0.0370			0.0400		0.0509
	Deviation of Maximum Amount (No. of times)		13	12		370			400		

Note: **1:Average of triplicate**
2: ND -Not detected

ANNEXURE : VII

Comparison of Organochlorine pesticide residues in raw water samples and bottled water samplescollected from the plant.

			Residues (mg/l)										
S. No.	**Name**	**α-HCH**	**β-HCH**	**γ-HCH**	**δ-HCH**	**α- Endosulfan**	**β-endosulfan**	**Heptachlor**	**Aldrin**	**Dieldrin**	**DDT**	**DDD**	**DDE**	**Total**
1.	Volga Plant	ND	ND	0.0055	ND	0.0017	ND	ND	ND	0.0019	0.0028	ND	ND	0.0119
	Volga BW	ND	ND	0.0028	ND	ND	0.0002	ND	ND	ND	0.0027	0.0002	0.0003	0.0061
2.	Bailley Plant	ND	ND	0.0057	ND	ND	ND	ND	ND	0.0006	0.0019	0.0008	0.0013	0.0103
	Bailley BW	ND	ND	0.0029	ND	ND	ND	ND	ND	ND	0.0014	ND	ND	0.0042
3.	Paras Plant	ND	ND	0.0043	ND	ND	ND	ND	ND	ND	0.0017	ND	0.0017	0.0077
	Paras BW	ND	ND	0.0036	ND	ND	ND	ND	ND	ND	0.0005	ND	0.0003	0.0043
4.	Bisleri Plant	ND	ND	0.0041	ND	ND	ND	0.0005	ND	ND	0.0015	ND	0.0008	0.0069
	Bisleri BW	ND	ND	0.0022	ND	ND	ND	ND	ND	ND	0.0005	ND	0.0003	0.0003
5.	Minscot plant	ND	ND	0.0027	ND	ND	ND	ND	ND	ND	0.0012	ND	ND	0.0039
	Minscot BW	ND	ND	0.0014	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	0.0016
6	t	ND	ND	0.0055	ND	ND	ND	ND	ND	ND	0.001	ND	0.0005	0.0070
	Aquaplus BW	ND	ND	0.0033	ND	ND	ND	ND	ND	ND	0.0009	ND	0.0004	0.0046

Note:

1: In all cases of raw water samples average of triplicate.

2: In all cases of bottled water average of 2 bottled water samples (triplicate of each)

3: ND- Not detected

4: BW- Bottled Water

ANNEXURE :VIII

Comparison of Organophosphorus Pesticide Residues in Raw water sample collected from the plants and the bottled water samples.

		Residues (mg/l)								
S.No.	**Name**	**Dimethoate**	**Phosphamido**	**Methyl Parath**	**Chlorpyrifos**	**Diazinon**	**Profenofos**	**Malathion**	**Parathion**	**Total**
1.	Volga Plant	0.1122	ND	0.0093	0.0087	ND	ND	0.025	0.0064	0.1616
	Volga BW	ND	ND	ND	0.0061	ND	ND	0.01925	ND	0.0254
2.	Bailley Plant	0.0402	ND	0.0005	0.0071	ND	ND	0.0114	ND	0.0592
	Bailley BW	ND	ND	ND	0.0037	ND	ND	0.0091	ND	0.0128
3.	Paras Plant	ND	ND	ND	0.006	ND	ND	0.0135	ND	0.0195
	Paras BW	ND	ND	ND	0.0031	ND	ND	0.01135	ND	0.0145
4.	Bisleri Plant	ND	ND	ND	0.011	ND	ND	0.0649	ND	0.0759
	Bisleri BW	ND	ND	ND	0.00665	ND	ND	0.0298	ND	0.0365
5.	Minscot plant	ND	ND	ND	0.005	ND	ND	0.021	ND	0.0260
	Minscot BW	ND	ND	ND	0.0019	ND	ND	0.00135	ND	0.0033
6.	Aquaplus Plant	ND	ND	0.0001	0.022	ND	ND	0.042	ND	0.0641
	Aquaplus BW	ND	ND	ND	0.0096	ND	ND	0.038	ND	0.0476

Note:

1: In all cases of raw water samples average of triplicate.

2: In all cases of bottled water average of 2 bottled water samples (triplicate of each)

3: ND- Not detected

4: BW- Bottled Water

Total Pesticide Residues in different brands of bottled water collected from Delhi and adjoining areas.

			Residues (mg/l)		
	Name	**Batch no. as per the label**	**Total Organochlorines**	**Total Organophosphorus**	**Total Organochlorines+Organophosphorus**
1	Bisleri-1	719	0.0043	0.0509	0.0552
2	Bisleri-2	29	0.0017	0.0220	0.0237
3	Aquafina-1	B-38	0.0010	0.0044	0.0054
4	Aquafina-2	B-39	0.0007	0.0010	0.0017
5	Kinley-1	92	0.0021	0.0119	0.0140
6	Kinley-2	99	0.0003	0.0003	0.0006
7	No 1 McDowell-1	A	0.0054	0.0496	0.0550
8	No 1 McDowell-2	B	0.0039	0.0255	0.0294
9	Paras-1	787	0.0046	0.015	0.0196
10	Paras-2	1608	0.0040	0.0139	0.0179
11	Bailley-1	2202	0.0111	0.0098	0.0209
12	Bailley-2	2102	0.0056	0.0158	0.0214
13	Pure life-1	INUOEPNS	0.0040	0.0036	0.0076
14	Pure life-2	INUOPANS	0.0032	0.0036	0.0068
15	Volga-1	A365	0.0059	0.0206	0.0265
16	Volga-2	A366	0.0064	0.0302	0.0366
17	Kingfisher-1	IB003	0.0039	0.0250	0.0289
18	Kingfisher-2	IB006	0.0045	0.0164	0.0209
19	Prime-1	4	0.0032	0.0039	0.0071
20	Prime-1	5	0.0024	0.0036	0.006
21	Aquaplus-1	B-93	0.0052	0.0468	0.052
22	Aquaplus-2	B-122	0.0040	0.0484	0.0524
23	Hello -1	377	0.0078	0.0151	0.0228
24	Hello -2	378	0.0077	0.0126	0.0203
25	KwencheR-1	B-128	0.0034	0.0207	0.0241
26	KwencheR-2	A:KK0102	0.0032	0.0223	0.0255
27	Minscot -1	8/185	0.0017	0.0030	0.0047
28	Minscot-2	5/182	0.0014	0.0035	0.0049
29	Himalayan-1	157Q	0.0020	ND	0.0020
30	Himalayan-2	187S	0.0009	ND	0.0009
31	Catch-1	IOW058	0.0023	0.0012	0.0035
32	Catch-2	IOW053	0.0015	0.0005	0.002
33	Evian-1	-	ND	ND	ND
34	Evian-2	-	ND	ND	ND
	Average Quality		***0.003728***	***0.016703***	***0.019384***

Note:

1: Average of triplicates

2: NA- Not available