# Heavy metal contamination of water bodies, soils and vegetables in peri urban areas of Bangalore city of India

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**Abstract**
A study was conducted in peri-urban Bangalore where city wastewaters from four water bodies viz, Bellandur, Varthur, Byramangala and Nagavara tanks were used for cultivation of vegetable crops to assess heavy metal contamination of water, soil and vegetables. Analyses revealed high concentrations of Cd and Cr in waters of all the tanks, exceeding the recommended levels of 0.01 and 0.1 mg/L respectively. Concentration of Cd was highest in waters of Bellandur (0.039mg/L) and concentration of Cr was highest in waters of Byramangala tank (0.311mg/L). Among all the tanks, Bellandur and Varthur were found to be highly contaminated with Cd, Pb and Ni. The concentration of heavy metals (mg/kg) in soils receiving sewage waters from the four tanks ranged from 1.92 -2.90 for Cd, 47.04-68.12 for Pb, 35.08-92.78 for Cr and 48.2-57.3 for Ni. The Cd and Pb contents were highest in the soils near Varthur and Bellandur tanks, while Cr was highest in soils near Byramangala. A similar trend was observed with respect to heavy metal content of vegetables. Among all the vegetables, Amaranthus and palak, accumulated higher concentrations of heavy metals followed by carrot and radish. The Cd concentration of all the vegetables grown near Varthur and Bellandur tanks exceeded the PFA safe limit. Pb and Ni concentrations exceeded the safe limits in all the vegetables in all the tank areas.

**Key words**
Cadmium, lead, chromium, nickel, soil, vegetables.

## Introduction
Contamination of environment with toxic heavy metals has become one of the major causes of concern for human kind. Heavy metals in surface water bodies, ground water and soils can be either from natural or anthropogenic sources. Currently, anthropogenic inputs of metals exceed natural inputs due to increased urbanization and industrialization. Industrial wastes, atmospheric deposition from crowded cities and other domestic wastes are among the major sources of heavy metals in the urban sewage (Sorme and Lagervist 2002). Bellandur tank, Varthur tank, Byramangala tank and Nagavara tank are important water bodies of Bangalore. These tanks are part of the city drainage system that drain untreated and partially treated domestic sewerage and industrial effluents from a number of small scale units like garment factories, electroplating industries, distilleries, etc. The farmers in peri urban areas use water from these tanks for cultivation of vegetables. Soils receiving these waters accumulate heavy metals to varying degrees depending on their concentration in water and the frequency of irrigation. The heavy metals are absorbed by crops along with other essential plant nutrients. Contamination of soils and crops with these metals may have adverse effects on soil, plants, animals and human beings. The present study was aimed at finding out the levels of contamination of four toxic heavy metals viz. cadmium (Cd), lead (Pb), chromium (Cr), and Nickel (Ni) in four tanks, in the surrounding soils receiving water of these tanks and the vegetables grown in those soils.

## Methods
Surveys have been conducted from 2005-2008 in the villages surrounding Bellandur , Varthur , Byramangala and Nagavara tanks where farmers were using water from the tanks for cultivation of vegetables. A farm which is away from these tanks and where bore well water was used for growing vegetables was included for study as uncontaminated control site. The water samples from all four tanks and bore well of uncontaminated site were collected in polyethylene bottles for analysis. Soil samples and samples of six vegetables viz. amaranthus, palak, carrot, radish, tomato and beans from the farmers fields were also collected. Soil and vegetable samples from uncontaminated field were also collected in similar fashion. Soil samples were dried at room temperature and ground to fine powder. Vegetable samples were dried in oven at 80$^{o}$ C, powdered and passed through a 2mm sieve. The soil and vegetable samples were digested with triacid

mixure ( $HNO_3$, $HClO_4$ and $H_2SO_4$ in 5:1:1 ratio) (Allen *et al.* 1986). The total heavy metal contents in water samples, digested soil and vegetable samples were estimated using Perkin Elmer Flame Atomic Absorption Spectrophotometer. The standard deviation of each result was estimated.

**Results**

*Heavy metals in tank waters*

Mean heavy metal concentration (mg/L) of water from the four water bodies is given in Table 1. Metal conentrations ranged from 0.014-0.039 for Cd, 0.039-0.075 for Pb, 0.120-0.291 for Cr and 0.027-0.042 mg/L for Ni. In comparison with the standard guidelines of irrigation water (Pescod 1992), it was found that mean Cd and Cr contents of all the tank waters exceeded the recommended levels of 0.01 and 0.1 mg/L respectively, while contents of Pb and Ni were within safe limits. The levels of all the four heavy metals were within safe limits in bore well waters of uncontaminated site. Among all the four tanks, Bellandur and Varthur tanks were highly contaminated with Cd, Pb and Ni. This may be due to rapid industrialization and urbanization around these tanks, increased number of IT industries, electroplating industries and a number of small scale industrial units and releasing of waste waters and other solid wastes from these units into these tanks through storm water drains. The higher levels of Cr in Byramangala tank can be attributed to waste waters and effluents released from the chromium electroplating industries in the surrounding areas. The mean Cd, Cr and Ni contents in waters of four tanks were about 20-25 times higher than the bore well waters of uncontaminated site.

*Heavy metals in soils*

The concentration of heavy metals (mg/kg) in agricultural soils receiving sewage waters from the four tanks ranged from 1.92 -2.90 for Cd, 47.04-68.12 for Pb, 35.08-92.78 for Cr and 48.2-57.3 for Ni (Table 2). The mean Cd, Pb, Cr and Ni contents of uncontaminated site were 0.90, 39.6, 34.2 and 34.9 mg/kg respectively. The Cd content was highest (2.90 mg/kg) in the soils near Varthur tank followed by the soils near Bellandur tank (2.38 mg/kg). These elevated concentrations may be due to long term use of tank waters for irrigation. The mean concentration of Pb was also highest in soils near Varthur and Bellandur tanks (68.12 and 64.9 mg/kg respectively). This can be attributed to nearness to highway, increased traffic, atmospheric deposition and prolonged use of tank waters. The mean concentration of Cr was highest in soils near Byramangala (92.78 mg/kg ).This might be due to long term use of tank water which contained the waste water effluents discharged from chromium electroplating industries. Ni content was highest in soils near Vathur (57.3 mg/kg).This may be due to effluents discharged from electroplating industries around the tank.

*Heavy metals in vegetables*

Figure 1 shows highest content of Cd in almost all the vegetables grown near Bellandur and Varthur tanks exceeding PFA safe limits of 1.5 mg/kg. This is likely due to the high concentration of Cd in the tank waters, long term use of tank waters for vegetable cultivation and high content of Cd in the soils. Leafy vegetables, amaranthus and palak, accumulated maximum levels of Cd followed by root vegetables carrot and radish. This may be due to genotypic variations in different species to absorb or translocate toxic metals (Patterson 1977). The Cd content of vegetables in Varthur and Bellandur was 6-16 and 6-20 folds higher than that of Cd content of vegetables in the uncontaminated site. The mean Pb concentration of all the vegetables was above PFA safe limit of 2.5ppm irrespective of the sites from where they were collected though vegetables grown near Bellandur tank and Varthur tank accumulated higher concentrations of Pb compared to vegetables grown near the other two tanks (Figure 2). The elevated levels of Pb in vegetables near Varthur and Bellandur may be attributed to long term use of tank waters, high levels of Pb in these tanks, near ness of the fields to highways and atmospheric deposition. The highest concentration of Cr was found in vegetables grown near Byramangala tank. Except tomato and beans all the leafy and root vegetables contained Cr levels exceeding PFA safe limit of 20 mg/kg (Figure 3).

The effluents discharged into the Byramangala tank from the surrounding industrial units and long term use of the tank waters for vegetable cultivation might be the cause of higher levels of Cr in vegetables near Byramangala tank. Cr concentration of vegetables near this tank was about 5 folds higher than that of uncontaminated site.The mean Ni concentration of all the vegetables grown near all the tanks exceeded PFA safe limit of 1.5mg/kg for human consumption though the levels in vegetables near Bellandur tank were higher compred to that of other tank areas (Figure 4). The mean concentration was higher in leafy vegetables amaranthus and palak followed by root vegetables radish and carrot. The mean Ni concentration in vegetables near Bellandur tank was about 10 folds higher than that of vegetables of uncontaminated site.

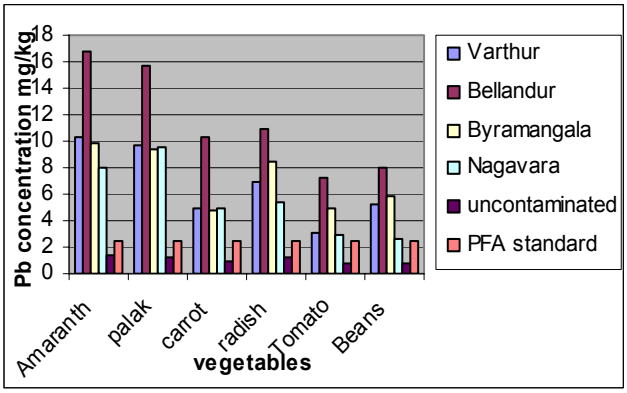


**Figure 1. Cd content of vegetables.**

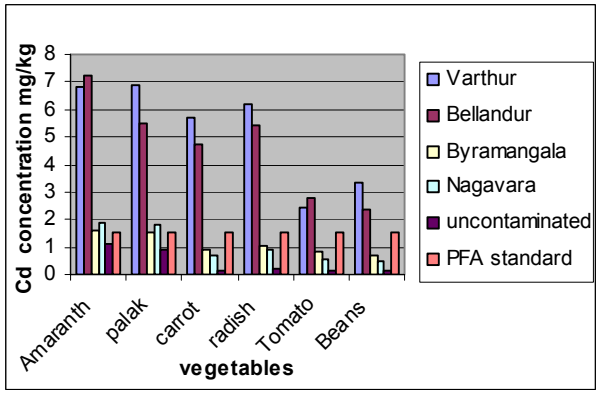


**Figure 2. Pb content of vegetables.**

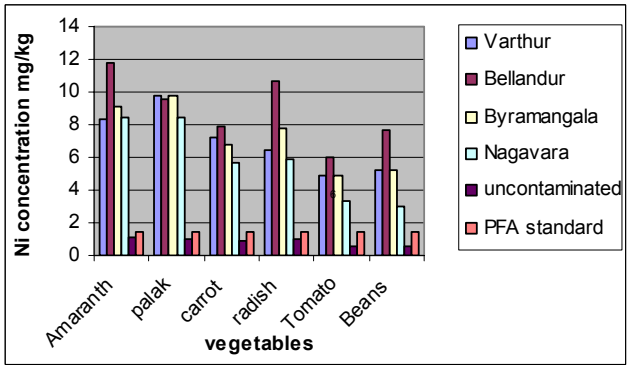


**Figure 3. Cr content of vegetables.**

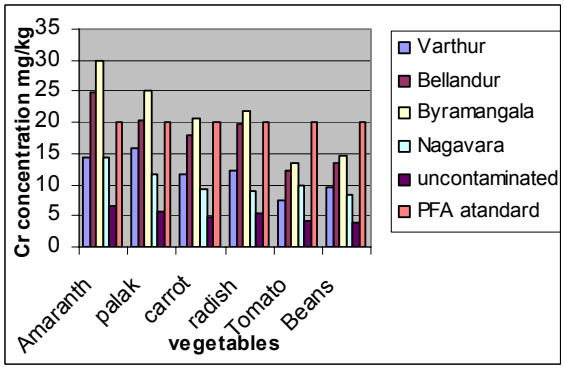


**Figure 4. Ni content of vegetables.**

**Table 1. Heavy Metal Concentrations (mg/L) In Different Water Bodies of Bangalore.**

| Location | | Cd | Pb | Cr | Ni |
|---|---|---|---|---|---|
| Varthur tank | Mean | 0.033 | 0.075 | 0.289 | 0.039 |
| n: 36 | Std. dev | 0.009 | 0.039 | 0.189 | 0.036 |
| Bellandur tank | Mean | 0.039 | 0.065 | 0.291 | 0.042 |
| n:36 | Std. dev | 0.008 | 0.025 | 0.198 | 0.033 |
| Byramangala tank | Mean | 0.022 | 0.059 | 0.311 | 0.04 |
| n:36 | Std. dev | 0.011 | 0.024 | 0.215 | 0.03 |
| Nagavara tank | Mean | 0.014 | 0.039 | 0.12 | 0.027 |
| n:24 | Std. dev | 0.002 | 0.016 | 0.067 | 0.018 |
| Borewell of Uncontaminated site | Mean | 0.002 | BDL | 0.015 | 0.0016 |
| n: 12 | Std. dev | 0.0008 | - | 0.007 | 0.0008 |
| Safe limit* | | 0.01 | 0.5 | 0.1 | 0.2 |

*Source: Pescod, 1992. n: number of samples

**Table 2. Heavy Metal Concentrations (mg/kg) In Soils Receiving Sewage Water From Different Water Bodies in Bangalore.**

| Location | | Cd | Pb | Cr | Ni |
|---|---|---|---|---|---|
| Near Varthur tank | Mean | 2.9 | 68.12 | 56.5 | 57.3 |
| n: 36 | Std. dev | 0.7 | 18.7 | 14.64 | 19.9 |
| Near Bellandur tank | Mean | 2.38 | 64.9 | 51.8 | 45.7 |
| n: 36 | Std. dev | 0.67 | 12.5 | 13.4 | 14.5 |
| Near Byramangala tank | Mean | 2.06 | 55.02 | 92.78 | 46.1 |
| n: 36 | Std. dev | 0.71 | 7.67 | 14.05 | 79 |
| Near Nagavara tank | Mean | 1.92 | 47.04 | 35.08 | 48.2 |
| n: 24 | Std. dev | 0.25 | 7.67 | 7.83 | 9.09 |
| Uncontaminated field | Mean | 0.9 | 39.6 | 34.2 | 34.9 |
| n: 12 | Std. dev | 0.22 | 7.47 | 6.31 | 8 |
| Safe limit* | | 1.6-3.0 | 90-300 | 100-120 | 48-75 |

*Source; Kabata and Pendias (1984) n: number of samples

## Conclusion

It can be concluded from the above study that the waters of 4 major water bodies of Bangalore were contaminated with heavy metals especially Cd and Cr. Though the levels of heavy metals in the soils under study were within safe limits as per the standards, the levels in vegetables exceeded official Indian standards (Awasthi 2000) by many folds. Leafy vegetables accumulated highest concentrations followed by root and fruit vegetables. Vegetables grown with waters of Varthur and Bellandur tank accumulated higher concentrations of Cd, Pb and Ni whereas vegetables grown with waters of Byramangala tank accumulated very high levels of Cr. The high levels of heavy metals in tank waters, soils and vegetables can be attributed to discharge of municipal and industrial waste waters into the water bodies.

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