Toxic heavy metals in ambient air of Kathmandu

A report submitted to

Environment and Public Health Organisation (ENPHO)
Thapagaon, New baneshwor,
Kathmandu

Submitted by

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2000

1. Introduction

Kathmandu, the capital city of Nepal is getting heavily polluted day by day. According to a national survey (NPC/IUCN, 1991) Bagmati Zone is one of the Hot spots from pollution point of view. All industrial plants with high pollution scores in Bagmati zone falls within Kathmandu Valley. Besides this the main source of air pollution is also due to uncontrolled and ever increasing vehicular emissions. There are nearly 100,000 vehiles rolling through the streets of Kathmandu Valley. The fuel used in these vehicles is leaded. In 1995/96 annual petrol and diesel consumption in the valley amounted to 11,911 KL and 30,720 KL, respectively, with 8-9 % increment per year (Nepal Oil Corporation, Kathmandu, personal communication). Due to the very physical feature of Kathmandu valley, the exhaust gases emitted by these vehicles remain in the atmosphere of the valley for longer period. According to Bhattrai and Shrestha (1981), lead content in the dust of different roadside ranged between 17 to 544 ppm. Devkota et al. (1997) have recorded 7.885 μg/g Pb in *Parmelia simplicior* and 0.378 μg/g Cd in *Lobaria retigera*, collected from Sivapuri Watershed and wildlife Conservation Area. These data do not reflect the exact content of toxic heavy metals like Pb, Cd, and Cr in air of Kathmandu valley. Therefore, in the present study the level of these toxic metal like Pb, Cd and Cr has been measured in different places of Kathmandu using lichens through biomonitoring technique

There is a long history of using lichens as indicators of air pollution (Sernander 1926, Nylander 1866, James 1973, Seaward et al. 1981, Garty and Hagemeyer 1988, Brown 1984, Sawidis et al. 1995). Lichens accumulate and tolerate metals to a high degree because of their relatively large surface area, and slow growth rate. Because of the lack of cuticle and epidermis, and their poikilohydric nature, accumulation of air borne metals occure by particle trapping (Olmez et al. 1985), active uptake of anion, passive adsorption of cations and ion exchange (Nieboer and Richardson 1981). Generally, there are three categories of lichens -one group of lichen disappear when the pollution starts, the second group are resistance to pollution, and the third group appears when pollution begins (Garty et al. 1985). Most of the fruticose lichens are sensitive (Garty et al. 1985) whereas foliose and crustose lichens such as *Cladonia convoluta, C. rangiformis, Neophuscelia pulla, Xanthoparmelia taractica, Xanthoria sp.* etc are resistant species and have also been reported as indicator of Copper mining areas in northern Greece (Chettri et al. 1997b). Therefore, one of these groups is available in urban areas and the metal content in their thalli will manifest the approximate level of Heavy metals present in the environment.

For decades, lichens have been known as good accumulation organisms (or biomonitors) for heavy metals and other inorganic air pollutants (Lounamaa 1965; Nieboer et al. 1978; Puckett, 1988; Herzig, 1993; Sawidis et al. 1995; Chettri et al., 1997a,b). Application of biomonitors is the one of the suiTable method to monitor these metals in Kathamndu, as lichens are available in and around Kathmandu (Chettri et al. 1999). There is very close statistical relationship between the accumulated heavy metal contents in lichens and the heavy metal pollution measured in air (Herzig, 1993; Sloof, 1993). For example, remarkable correlation was found between the deposition values and the corresponding accumulation values of exposed samples of *Hypogymnia physodes* in an emission related examination around a Danish steel works (Pilegaard, 1979). Depending on these facts and mechanisms involved in metal accumulation in lichens, it clearly indicates that the level of heavy metal accumulation in a particular site in their thalli reflect the heavy metal concentrations in the ambient air.

2. Methodology

The lichen species collected from Namabuddha, a clean area in Kavre district, were used for active monitoring. About 20 places in Kathmandu were selected for active monitoring of toxic heavy metals. The name of the places where lichens were transplanted sites is given in Table 1. The collected lichen species from Namabuddha, were exposed for 3 month (December 24th – March 24th2000) in different sampling sites. After 3 months, the transplanted lichens were collected and cleaned in dry condition and representative samples were prepared. Lichens, which were already existed on trees at different sampling sites of Kathmandu were also collected, cleaned and representatve samples were prepared for passive monitoring of toxic heavy metals using the technique of. Toxic heavy metals like Pb, Cd and Cr were measured in atomic absorption spectrometer (as mentioned in Sawidis *et al*. 1995 and Chettri *et al* 1997).

Table 1. List of sites in Kathmandu where lichens were transplanted for monitoring toxic metals and their number

No	Collected for control and Transplanted sites	No. of lichen species
C	Namabuddha, collected for CONTROL	10
1	Deparment of Botany, Kirtipur	3
2	RIBS school, Kalanki	5
3	NCCN compound, Swyambhu	4
4	Police beat house, Kalimati	3
5	Back side of ASCOL, Thamel	5
6	TU gate, Balkhu	5
7	Birendra Int. Convention Hall, Naya Baneshwor	3
8	Putalisadak	4
9	TU teaching hospital, Maharajganj	4
10	Sherpa Monastry, Bauddha	4
11	Dept. Meteorology, Airport	4
12	Xavier Academy, Lazimpat	4
13	Back of Police Beat House, Gaushala	5
14	300m w of Chabhiel square, Chabil	4
15	In park area of Ratnapark	2
16	Police Station, Hanumandhoka	5
17	New summit School, Maitidevi	4
18	Army Compound, Bhadrakali	6
19	Back of Trichandra Campus, Ghantaghar	3
20	Back of Public Adm. Campus, Tripureshwor	7

3. Results and discussion

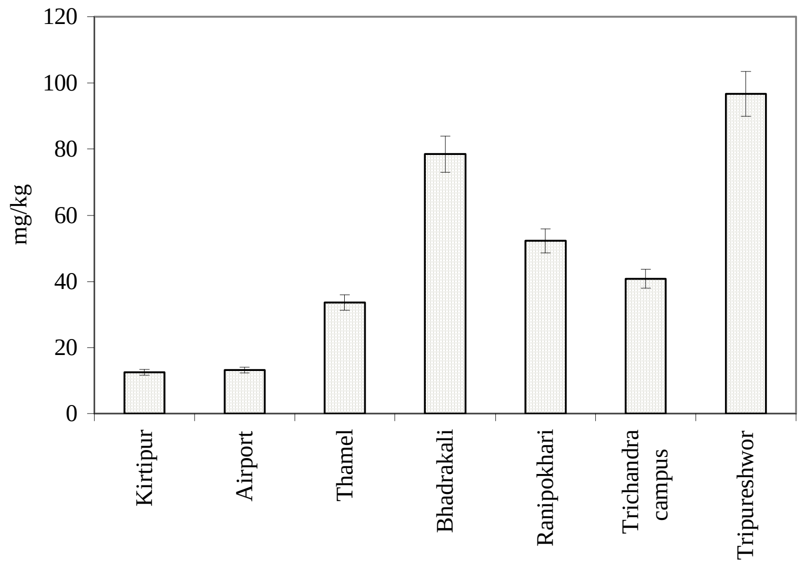
The concentrations of Pb, Cd and Cr in different places of Kathmandu were monitored through transplantation of lichens during December 1999 to March 2000. The level of different toxic metals at different transplanted sites has been given in figures 1,2 and 3. The level of toxic metals (Pb, Cd and Cr) in lichens collected from Namabuddha (C) has been considered for background reference.

Out of the different lichen species investigated for lead, chromium and cadmium monitoring, only four species of *Parmelia* has been identified as suiTable species for biomonitoring through transplantation technique.

3.1 Lead

Level of lead ranged from 1.39 mg/kg in *Cladonia coniocraea* to 8 mg/kg in *Parmelia reticulata* at Namabuddha, a clean area near Panauti, Kavre district, which has been considered

Fig. 1. Pb-content in lichens that existed in differnt sampling sites in Kathmandu



for background reference. Lichens collected from Namabuddha has been used for active monitoring. Concentration of lead ranged from 12.5 mg/kg at Kirtipur to 96.74 mg/kg at Tripureshwor in lichens that existed in the sampling site since their birth (Fig. 1).

Fig. 2. Pb content in lichen spp. transplanted for 3 months at differnt places of Kathmandu

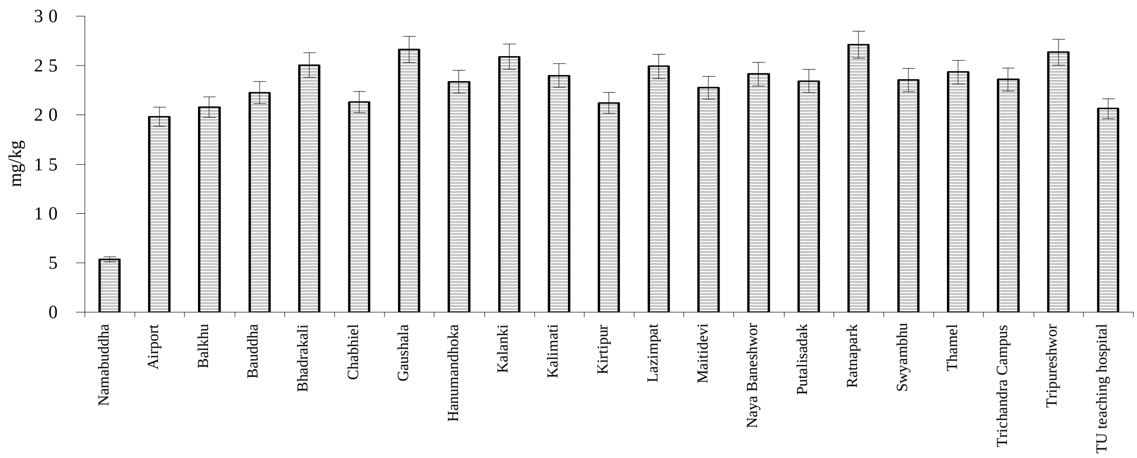
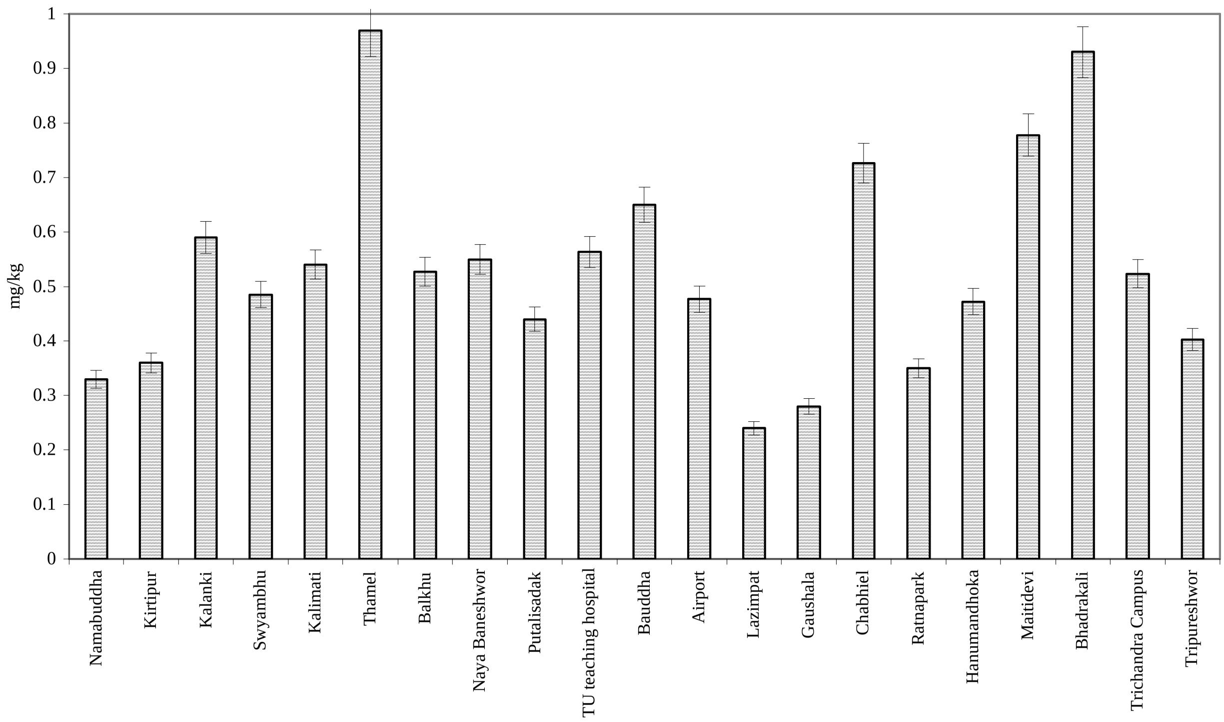


Fig. 4. Cd content in lichens transplanted for 3 months at different places of Kathmandu

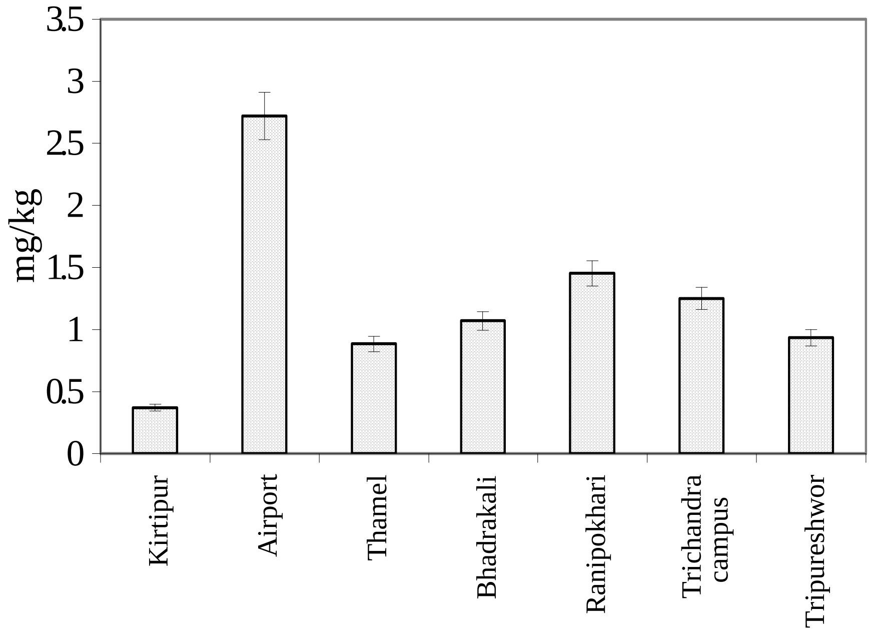


The concentration of lead in transplanted lichen species in Kathmandu ranged from 20 to 27 mg/kg. Statistical analysis using one way ANOVA followed by Duncan's multiple range test indicated that the level of Pb is significantly higher (P=0.05) than in Namabuddha. Although, there are statistical insignificant differences in Pb concentrations among different transplanted sites in Kathmandu, some variations can be observed (Fig. 2). The concentrations of Pb in transplanted lichens at Kirtipur, Swyambhu, Balkhu, Airport, Maharajganj and Chabil area were more or less same (20-21mg/kg), indicating more or less similar Pb concentrations in air of these places. The lichen transplanted places like Hanumandhoka, Maitidevi, Putalisadak, Thamel, Trichandra campus (back side), Kalimati, Nayabaneshwor Lazimpat and Bhadrakali showed mean Pb concentration of 23-25mg/kg. Highest Pb concentrations (mean) in transplanted lichens were found in Kalaki, Gaushala, Ratnapark and Tripureshwor area (26-27mg/kg). The reasons for the high Pb accumulation in the lichens transplanted at Kalanki, Gaushala and from Tripureshwor must be due to high traffic and more emission by vehicles due to slight inclination of road at these sites.

3.2 Cadmium

Mean Cadmium concentrations in lichens already existed in different sites of Kathmandu ranged from 0.37 mg/kg in Kirtipur to 2.72 mg/kg in Airport. Passive biomonitoring using lichens showed high cadmium concentrations in Bhadrakali, Ranipokhari and Trichandra campus area (Fig. 3).

Fig. 3. Cd-content in lichens that existed at different sampling sites of Kathmandu.



Mean Cadmium concentrations in lichens from background area i.e. Namabuddha was 0.33 mg/kg and was statistically not significantly (P=0.05) different than in transplanted lichens at Kirtipur, Lazimpat, Gaushala and Ratnapark. A significantly increased (P=0.05) level of cadmium accumulation has been observed in lichens transplanted at Thamel, Chabil, Maitidevi and Bhadrakali than in other transplanted areas (Fig. 4). High level of Cd in these areas must have contributed by more traffic. Cadmium comes from lubricating motor oil, tires and galvanized parts of vehicles. Cadmium concentrations range from 0.07 to 0.10 ppm in diesel oils and 0.20 to 0.026 ppm in lubricating oils. Cadmium in automobile tires ranges from 20 to 90 ppm. (Kannan, 1997).

3.3 Chromium

Passive biomonitoring of Chromium using lichens which already existed in sampling sites indicated that its level ranged from 1.25 in Airport to 13.9 mg/kg Thamel, Ranipokhari and Tripureshwor (Fig. 5).

Chromium concentrations in transplanted lichens at different sites ranged from 2.9 mg/kg at Putalisadak to 14 mg/kg at Chabhiel (Fig. 6). Chromium concentrations in transplanted lichens indicated that Swyambhu, Gaushala, Chabhel, Ratnapark, Bhadrakali, Trichandra campus and Tripureshwor have significantly (P=0.05) higher concentrations of Cr than in background (Namabuddha) and other places of Kathmandu. Generally chromium concentration in clean environment is very poor, even near mining areas (Chettri et al., 1997b). Uptake of this metal occurs as hexavalent chromate (CrO_4^{2-}) which, however, is rapidly reduced to Cr^{3+} in soil. The trivalent form of Cr is absorbed minimally by root and its translocation from root to other parts is low (Streit and Stumm, 1993). High chromium concentrations in transplanted lichens at Swyambhu, Gaushala, Chabhel, Ratnapark, Bhadrakali, Trichandra campus and Tripureshwor must have occurred through deposits of total suspended particles (TSP) over the lichen surface, as it is the only way to accumulate metals in lichens. It, therefore, clearly indicated that the TSP in theses sites are contaminated with chromium, which may be due to high traffic and/or more carpet industries.

Fig. 5 Cr-content in lichens that existed in differnt sampling sites in Kathmandu

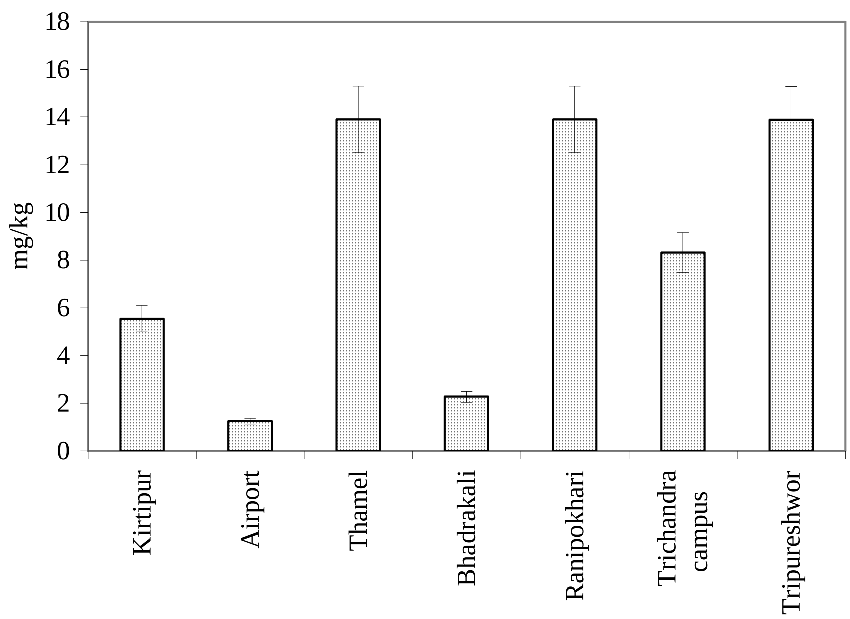
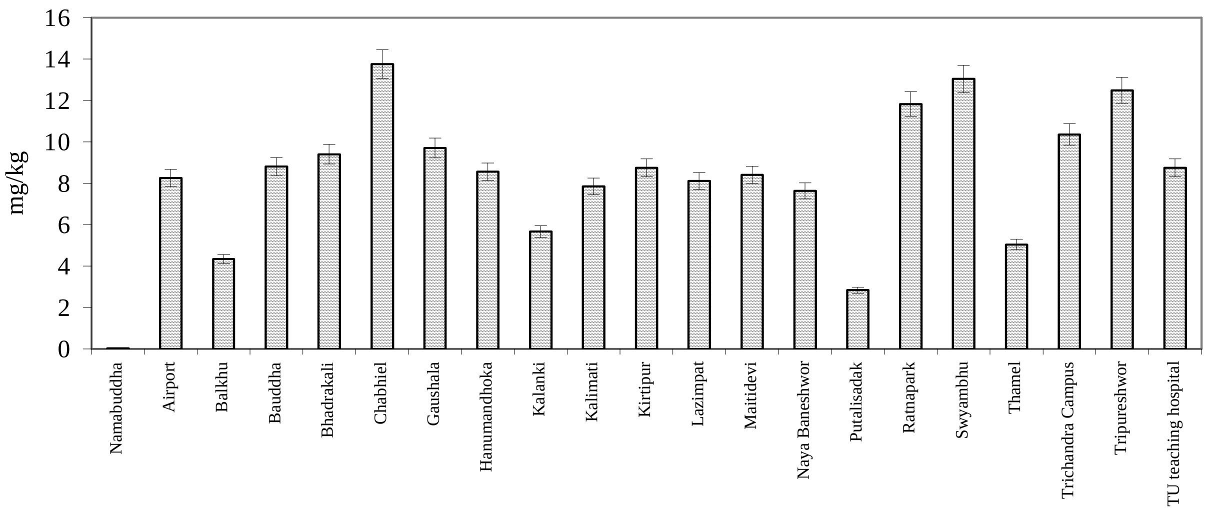


Fig. 6. Cr content in lichens transplanted for 3 months at differnt places of Kathmandu



4. Conclusions

From the present study it can be concluded that lichen can reflect the level of toxic heavy metals in our environment. Both active and passive monitoring of lichens indicated that the highest concentrations of lead is present in the ambient air of high vehicle traffic areas like Tripureshwor, Ratnapark, Bhadrakali Gaushala and Kalanki. Similarly, cadmium concentrations are also high in heavy traffic areas like Thamel (ASCOL), Bhadrakali, Maitidevi and Chabiel area. Passive monitoring indicated high Cd contamination in Airport area. High concentrations of chromium has been observed in passively monitored lichens at Thamel, Ranipokhari and Tripureshwor, all these sites are with heavy traffic. Active monitoring indicated high Cr concentrations at Swyambhu, Chabhiel, Ratnapark, Bhadrakali and Tripureshwor area.

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