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ASSESSING TOXIC METALS CONTAMINATION IN SOIL, WATER AND PLANT BODIES AROUND AN INDUSTRIAL BELT

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ABSTRACT

Surface soil (46 nos.), water (32 nos.) and plant/crop (34 nos.) samples were collected around Vapi industrial belt, Gujarat (India) in order to assess toxic metal contamination in surface soil, water sources and plant bodies. The results revealed that about 48, 100, 6 and 6% soils belonged to 'deficient to marginal' category with respect to Fe, Mn, Cu and Zn, respectively. The content of DTPA - Pb, Co, Ni and Cd in soils were also below permissible limit / maximum threshold value. Only few water sources contained Fe, Mn, Cu, Zn, Ni and Cd metals and that too within permissible limit. BOD and COD of water sources were above prescribed limit. Pb and Co content of all water sources were within maximum permissible limit and thus were safe. Fe in all plant/crop samples, Cu in five, Zn in nine, Pb in nineteen, Ni in fourteen and Cd only in six plant/crop samples were found to cross the maximum permissible limit and as a consequence might become toxic / harmful.

KEYWORDS: Toxic Metals, Contamination, Soil, Water Sources, Plant Body, Industrial Belt

INTRODUCTION

Many researchers and scientists from India and abroad, studied soil (Kumar and Srikantaswamy, 2012; Jayashree *et al*. 2012; Dheeba *et al*. 2012), water (Lokhande *et al*. 2011; Kumar *et al*. 2011) and plant samples (Sharma *et al*. 2009; Tanushree *et al*. 2011) from industrial and adjacent areas and reported varying degrees of contamination of heavy metals in soil-water-plant systems which ultimately were polluting not only aquatic resources and lives, but also agricultural and other plants/crops which later on became a part of food chain and thereby becoming harmful to human and animal kingdom. Vapi, situated in Valsad district of Gujarat (India) where thousands of various kinds individual industrial units are operative (CPCB, 1996; Bruno, 1995; Nagar, 1995). Rapid industrial development in Ankleshwar, Nandesvari and Vapi area of Gujarat has brought out enough exchequers on one hand, but on the other has invited environmental damage in certain regions of these areas. As a result of contamination and effluent discharges from industries, health hazards are observed common to the inhabitants and workers within and around this region. The ground water quality is also gradually deteriorating. The possibility of deterioration of soil, water quality and air pollution cannot be ruled out in these areas. Thus, the knowledge of variability, anthropogenic and natural origin of potentially harmful elements in soil, water and plant systems are of critical importance in the surrounding area of Vapi Industrial complex (Gujarat). Studies relating to toxic metal contamination in soil, water sources and plant/crop bodies in different villages from the surrounding area of Vapi industrial belt are scanty. So, it is highly worth to assess the extent of toxic metals contamination in surface soil, water sources and in some crops/plants in surrounding villages of Vapi industrial belt of Gujarat (India).

MATERIALS AND METHODS

Over View of Study Area

Vapi, situated on the banks of the Daman Ganga River, is the largest city and a municipality in Valsad district in the Southern part of Gujarat state (India). Vapi Industrial complex area houses 759 industries spreading over 11.4 km², of which 70% manufacture chemicals such as dyes and dye intermediates, pigments, pesticides, fine chemicals and pharmaceuticals. Other major industries include paper, packaging, pharmaceuticals, plastics, rubber, textile, wood, computer hardware and software, engineering workshops, glass, and food products (CPCB, 1996; Bruno, 1995; Nagar, 1995). Though wealth has been generated by rapid industrial development in this area, the price of this economic success has been and continues to be widespread environmental damage in many regions surrounding the Vapi Industrial belt. Cough, asthma and skin problems and other serious health hazards are clearly observed common to the inhabitants and workers within and around this region as a result of widespread contamination and effluent discharges from industries. The ground water quality is also deteriorating. Even during summer, chemicals are found to come out from several hand pumps. The pollution in this area is caused mainly due to piles of sludge and solid waste which are dumped indiscriminately on open ground and 'open roadside' ditches. Though there is continuous monitoring of pollution levels, yet there is not much improvement in pollution status. The possibility of soil, water and air pollution from unhygienic materials stored/dumped in open field due to transport as well as during loading and unloading particularly during high wind velocity and high rainfall seasons is common.

Collection of Soil, Water and Crop / Plant Samples and Analysis

Keeping Vapi Industrial Belt, (VIB) at center, 46 villages situated at the periphery of various distances of 100, 200, 400, 500, 600, 700, 800, 900 and 1000 m were selected for collection of surface soils, available water sources and some plant/crop samples. For each chosen village, a site / plot, nearby to water source from which water was being utilized for irrigation purposes by the farmers to some crops, was arbitrarily selected for soil sample collection. Representative soil samples were collected from all 46 villages. Similarly, water samples from different water sources (as were being used as irrigation) were collected. Representative plant/crop samples were collected only from those fields / farms from which soil sampling was done. The name of villages and their distance from Vapi industrial belt from where soil, water and plant/crop samples were collected are given in Table 1. Soil samples were processed and were analyzed for EC, pH and heavy metals (Fe, Mn, Cu, Zn, Pb, Co, Ni, and Cd). The water samples were used directly for analysis of EC, pH, BOD, COD. The plant samples were washed thoroughly, socked with clean cloth and then oven dried (at 60◦ C). The dried samples were grounded and were used for analysis of Fe, Mn, Zn, Cu, Pb, Co, Ni and Cd content.

Soil pH and Electrical conductivity were estimated in 1:2.5 soils: water suspension as described by (Jackson, 1973). DTPA- Extractable soil Fe, Mn, Cu, Zn, Pb, Co, Ni, Cd were determined by Atomic Absorption Spectrophotometer (Model-AAS 4141 A) following the method as suggested by Lindsay and Norvell, (1978). The pH and electrical conductivity of water samples were determined following standard procedure (Jackson, 1973). The chemical oxygen demand (COD) from water samples was determined by using a commercially available reflux condensation method, while the biological oxygen demand (BOD) was determined on the basis of measurement of dissolved oxygen content (Winkler's method) before and after oxidation matter of the sample by micro organisms I incubation period of 5 days at 20^0 C temperature as per standard procedure. Fe, Mn, Cu, Zn, Pb, Co, Ni and Cd from water samples were determined by AAS (Model-AAS 4141 A) following the method as suggested by Lindsay and Norvell (1978). 0.5 g grounded (powdery) plant / crop samples were digested with 15 ml Di-acid mixture on a hot plate for 48 hours. After the digestion, temperature was brought down to room temperature and then filtered. From filtrate toxic metal (Fe, Mn, Zn, Cu, Pb, Co, Ni and Cd) concentrations were determined by using AAS (Model-AAS 4141 A) following standard procedure.

RESULTS AND DISCUSSIONS

Surface Soils

$PH_{2.5}$ and $EC_{2.5}$

In general, pH of surface soils varied from 6.5 to 8.3 indicating neutral to moderately alkaline reaction with a mean value of 7.55 (Table 2). Soils from 11 villages belonged to neutral, 16 villages came under mildly alkaline and 17 villages were of moderately alkaline class. Salinity of soils ($EC_{2.5}$), in general, varied from 0.05 to 1.21 ds m^{-1} with a mean value of 0.24 dS m^{-1} (Table 2). Soils were normal in general (except one sample).

DTPA- extracted Fe, Mn, Cu, Zn, Pb, Co, Ni and Cd

DTPA- extracted Fe varied widely from 0.52 to 55.19 ppm (from deficient to adequate status) with a mean value of 15.20 ppm (Table 2). The results were supported by findings of Dheeba *et al*. (2012) for surface soil around industrial area, Tamil Nadu, India. Out of forty six samples, 9 (19.6 %), 13 (28.3%) and 24 (52.1%) samples belonged respectively to deficient, marginal and adequate category of DTPA- Fe (Table 3), indicating that there was no adverse / toxic effect of Fe in soil, rather about 48% soil samples were either deficient or marginal in DTPA- Fe and as a consequence might cause Fe deficiency symptoms in plants in near future, unless it is replenished through addition of organic matter /manure or some other means.

Similar findings in relation to critical limits of Fe were reported by Sharma (2001). Shaikh and Bhosle (2013) obtained iron concentration below the permissible range of 60 mg/kg in surface soils near Siddheshwar Dam, Maharashtra, India. DTPA extracted Mn (available manganese) in surface soils ranged from 2.69 to 7.84 ppm with a mean value 5.45 ppm (Table 2). Out of forty six (46) samples, 18(39.14%) and 28(60.86%) samples belonged respectively to deficient and marginal category of available (Table 3) Mn. All the soils were below the permissible threshold value (<30 ppm) of Mn and were well suitable for the agriculture. No adverse effect of contamination/ toxicity of Mn in soils were observed, rather 100% soil samples were either deficient or marginal category which in turn might cause Mn deficiency in future and thus is required to be corrected to avoid possible adverse effect on crop yield. However, slightly higher values of Mn (19.90, 6.39 ± 1.07 to 20.31 ± 3.42 and 12.59 ppm) were reported respectively by Odoi *et al.* (2011) in soils of industrial area of Ghana, Stephen and Oladele (2012) in top soils around the Iron- ore mining field Itakpe, Nigeria. DTPA extracted Zn (available zinc) in surface soils ranged from 0.08 to 7.84 ppm with a mean value 6.06 ppm (Table 2), out of forty six (46) samples, 2(4.35%), 1(2.17%) and 43(93.48%) samples belonged respectively to deficient, marginal and adequate category of available Zn (Table 3).

More or less, similar results were obtained by Odai *et al.* (2011) and Dheeba *et al*. (2012). Zn deficiency was also observed by Katyal and Datta (2004) and Somasundaram et al (2009). Similarly, DTPA extracted Cu (available copper) in surface soils ranged from 0.19 ppm to 22.15 ppm with a mean value 5.25 ppm (Table 2), indicating one, two and forty-three samples under deficient, marginal and adequate class respectively (Table 3). Data of Cu was supported by Gowd et al (2010), Sayyed and Sayadi (2011), and Kumar and Srikantaswamy (2012) for surface soils nearby to various Industrial complex. Further, available Zn and Cu content of all the soil samples were below the maximum permissible threshold value which clearly indicated that even though the villages were situated in surrounding area of Vapi industrial complex at varying distances, no adverse effect of contamination/toxicity of Zn and Cu were observed in soils, rather about 6.5% soil samples were either deficient or marginal in available Zn and Cu, where corrective measures should be taken as to avoid any Zn and Cu deficiency in near future. However, the differences in DTPA-extractable Fe, Mn, Cu and Zn content in soils of different villages situated at varying distance from Vapi industrial complex might be ascribed to varying soil pH, organic matter and nutrient removal by crop.

DTPA extracted Pb in surface soils ranged from 0.09 to 8.26 ppm with a mean value 1.89 ppm (Table 2), the highest and the lowest value being associated with village Dungra and Salvav & Dadra village respectively.The results corroborated with the findings of Gowd et al (2010) and Stephen and Oladele(2012). The comparatively less content of Pb in soils might also be possible as result of plant uptake as opined bt Dasaram et al. (2011). DTPA extracted Co ranged 4.28ppm to 15.32 ppm with a mean value 9.92 ppm (Table 2). The highest and the lowest Co content were recorded at Tukvada & Karaya village and Kunta village respectively. Krishna and Govil(2007) reported much higher Co content in surface sils from industrial area of Surat, Gujarat.which according to them might give rise to health hazard. However, both Pb and Co concentration in surface soils of all villages were below the permissible threshold value (Pb <100 and Co < 17 ppm) and were safe. DTPA- Cd was recorded only in soils of 26 villages and ranged from 0.02 to 0.009 ppm while, 20 villages did not detect Cd at all in surface soils situated between 100 and 600 m (except village Dabhel) distance from Vapi industrial belt. However, DTPA extracted Ni ranged from 1.02ppm to 5.70 ppm with a mean value 3.10 ppm in surface soils (Table 2). The highest and the lowest Ni content were recorded at Motidaman & Perera village and Valvada village respectively. In soils of industrrial zone of Mysore city, Karnataka Kumar and Srikantaswamy (2012) obtained 9.7 to 18 mg/kg of Ni. DTPA extracted Cd was detected only in 26 soil samples. samples containing Cd ranged from 0.02to 0.09 ppm. Results of lower levels of Cd concentration were supported by Stephen and Oladele (2012) in top soils around mining area of Nigeria. However, Ni and Cd content of soils from all villages were below maximum permissible threshold value (Ni <80 and Cd < 3 ppm) and were safe. Thus, contaminations or toxicity Pb, Co, Ni and Cd in soils (by virtue of their vicinity to Vapi industrial belt) owing to spreading of toxic metals by rain water and/or wind were not found severe at all. However, comparatively lower concentration of Pb, Co, Ni and Cd obtained in these soils might be due to the partial uptake of these elements by plants.

Water Sources

pH, EC, BOD and COD

pH of thirty two water sources ranged from 6.31 to 8.06 (neutral to moderately alkaline) with a mean value of 7.34 (Table 4). Water samples from twenty two, nine and one villages belonged to neutral, slightly alkaline and moderately alkaline category respectively. EC of thirty two water sources varied from 0.13 to 1.95 ds m^{-1} (Table 4) indicating excellent (C_1) to permissible (C_3) class i.e. safe to can't be used for irrigation in soils with restricted drainage. However, the mean water EC was 0.61 dS m^{-1} i.e. good (C_2) category. Eklaher village situated 700m distance from Vapi industrial belt recorded the highest salinity (1.95 dS m^{-1}) in water. six (18.75%) water sources belonged to excellent class (C_1) i.e. safe for irrigation, sixteen (50.00%) water sources belonged to good class (C_2) i.e. safe for irrigation but need moderately leaching and ten (31.25 %) water sources belonged to permissible class (C_3) i.e. can't be used for irrigation in soils with restricted drainage. As such no adverse effect due to effluent of industrial complex, Vapi could be ascertained on pH and EC of water sources. The variation in pH and salinity (EC) among water sources seemed to be due to kind of water sources variation in soil quality with location. All the water sources exhibited Biological oxygen demand (BOD) value higher than prescribed limit (30mg L^{-1}) with a variation from 62.2 (associated with Motidaman village) to 84.0 mg L^{-1} (associated with Chandor and Kocharva village) with a mean value 76.81 mg L^{-1} (Table 4). The higher value of BOD of irrigation water was reported by Saidi M. (2010). BOD higher than prescribed limit might create poor aeration problem (inadequate oxygen) affecting adversely micro- organisms activity in soil when such water are used as source for irrigation. All the water sources exhibited chemical oxygen demand (COD) value higher than prescribed limit (250mg L^{-1}). It varied widely from 136 (associated with Nanidaman village) to 304 mg L^{-1} (associated with Nahuli village) with mean value of 222.31 mg L^{-1} (Table 4). Dhakyanaika and Kumar (2010) obtained COD from 15.82–1062 mg/L in river Krishni in India while Yadav and Kumar (2011) reported COD value from 69–193 ppm in water of Kosi river, U.P., India. COD higher then prescribed limit in all studied water sources indicated presence of significant amount of contaminant / pollutant / organics in water sources.

Content of Fe, Mn, Cu, Zn, Pb, Co, Ni and Cd

All the water sources was found either free of Fe or below detectable limit indicating that 100 per cent sources studied were well within the maximum permissible limit <0.3 ppm and thus were safe (Table 4 & 5). Mn could be traced only in two water sources i.e. at village Rata and Karvad and contents were found well within the permissible limit of <0.05 ppm (Table 4 & 5). Reza and Sing (2010) found water samples of river system at Angul less contaminated with heavy metal Fe and Mn. The results indicated that the adverse effect of Fe and Mn due to effluent of Vapi industrial belt, on quality of water sources were practically nil. Cu was detected only in two water sources i.e. at village Nahuli (0.003 ppm) and Khadivad (0.083 ppm) (Table 4 & 5). However, water source from Khadivad village crossed the permissible limit of <0.05 ppm and was not safe for use. Likewise, Zn content was observed only six water sources, but Zn content in, these sources were found well within the permissible limit <5.0 ppm and hence, were safe for use (Table 4 & 5). Reza and Sing (2010), Puthiyasekar *et al*. (2010) and Pandey *et al.* (2010) observed low Cu and Zn contamination or below their permissible limit in river water and / or bore water. The results clearly showed that there was no or negligible admixture of Cu and Zn toxic metals with studied water sources of surrounding villages. All the water sources contained heavy metal Pb which ranged from 0.013 to 0.440 ppm with a mean value 0.011 ppm (Table 4). 13 water sources contained Pb above maximum permissible limit (<0.1 ppm), while 19 sources were well below maximum permissible limit (Table 5). Varying degree of Pb contamination might have occurred either through aerial deposition or run- off / rain water during monsoon.

As the water sources containing Pb above maximum permissible limit might affect human health and the health of aquatic eco system, such sources should not be used for irrigation to crops without prior treatment, for Pb might enter the plant system and ultimately in the food chain. In the industrial belt or in vicinity of industries, Lokhande *et al*. (2011) in Kasardi river Mumbai, India, Roy and Jogen (2011) in water bodies around Guwahati city, Assam, India, recorded respectively 33.9 to 8.6 mg/L, 2.036 mg/L ppm Pb and they were of the opinion that Pb content in water sources above permissible limit might pose potential health hazards. Toxic metal Co varying from 0.003 to 0.023 ppm with a mean value 0.011 ppm, was detected in all the water sources (Table 4). However, Co content in all samples was well below the maximum permissible limit (0.05-1.5 ppm) and were safe for irrigation purposes (Table 5). Bouraie *et al*. (2010) reported on the low concentrations of Co in surface river water of Egypt and concentrations were mainly within the permissible limit. Similarly, Ni was detected (0.015 ppm) only in one water source (at Dabhel village) and the value was found well within the maximum permissible limit <0.02 ppm (Table 4 & 5). The low levels of Ni was reported by Reza and Sing

(2010) in river system at Angul by Pandey *et al*. (2010) in water of Ganga at Varanasi (UP) and concentrations were mainly within the permissible limit. Cd was detected only in 14 water sources (one, three, two, two and five sources respectively from 600, 700, 800, 900 and 1000 m distance) which varied from 0.002 to 0.021 ppm with a mean value of 0.003 ppm (Table 4). However, Cd containing all the water sources were well below the permissible limit (0.01 ppm) (Table 4 & 5) and thus were safe for irrigation purposes to safe agricultural crops.

Crops / Plant Samples

Total content of Fe, Cu, Mn, Zn, Pb, Co, Ni and Cd

The result reveled (Table 6) that Fe and Mn were detected in 33 plant / crop samples. Fe varied widely from 66.8 to 1903.0 ppm and Mn 8.2 to 175.2 ppm. But, Fe content was well above the maximum permissible limit (5.0 ppm) in all 33 samples (Table 7). The results of Fe corroborated with the findings of Kumar *et al.* (2007) and Buszewski *et al*. (2009). No specific permissible limit for Mn is available. Chili (village Tukvada) recorded the highest Fe, while Mango plant samples (village Nanidaman) analyzed the lowest Fe and no Fe was detected in Jack fruit samples. The wide variation in Fe and Mn content in different plant / crops samples might be attributable to variation in uptake by different crop species and access / exposure of plants to varying Fe and Mn contaminated environment. The acceptable limit for human consumption of Fe is 8 to 11 mg/day for infants as well as adults (ATSDR, 1994). So, higher content of Fe in plant / crops might cause its translocation to the edible part making them harmful and / or toxic for human consumption (high intake of Fe particularly from vegetables like cabbage, cauliflower, Indian bean, might result into hepatic megaly, cardiac infraction and nephric malfunction). Cu, varying widely from 7.4 to 74.0 ppm with a mean value 19.0 ppm, was observed in all the plant / crop samples (Table 6). The lowest and the highest value of Cu were recorded in sugarcane (Tarakpardi village) and Mango plant samples (village Karaya) respectively. The reason for higher Cu absorption by plant from soil was mainly due to the higher DTPA- Cu in almost all the soils from where plant / Crop sample were taken.

However, only five plant (Mango, Tomato, Mango, Brinjal and Mango) samples from villages Mohangam (500m), Motidaman, Rata (900m), Kocharva, Karaya (1000m) showed Cu content above the maximum permissible limit (30.0 ppm) (Table 7). Buszewski *et al*. (2009) in Torun, Poland obtained Cu 35 mg/kg of plant dry mass, Miclean *et al.* (2000), in a mining area from North-Western Romania recorded 66.3–238.1 mg/kg of Cu in plants. Further, Bhattacharya *et al*. (2011) analyzing Cu concentration in street and leaf deposited dust in Anand city, India, reported 52 –130 mg/kg Cu in leaf sample. As Cu content >30.0 ppm in plant / crops might cause its translocation to the edible part also, making them harmful and toxic (hypertension, sporadic fever, uremias, coma etc.) for human consumption, precautionary measure should be taken for growing particularly leafy vegetables in the above five villages, as the edible part of vegetables containing Cu >10 ppm could be risky for human consumption. Only in nine plant samples (Guava, Jackfruit, Sapota, Sapota, Sugarcane, Cashew nut, Indian bean, Mango and Brinjal) obtained from villages Palset, Jamburi, Ranginvada, Cheeri, (600 m), Eklaher, Aambavadi, Nahuli (700 m), rata (900 m) and Kocharva (1000 m) Zn content was above the maximum permissible limit (50.0 ppm). However, Zn content varied widely from 3.4 to 103.8 ppm in plant / crop samples with a mean value of 34.64 ppm (Table 6) and the lowest and the highest Zn content recorded in sugarcane (Tarakpardi village) and cashew nut plant sample (village Aambavadi) respectively.

The reason for variation in Zn content was the same as discussed above. Buszewski *et al*. (2009) from Poland reported 75 mg/kg of Zn in plant dry mass, Rahman *et al*. (2010) obtained Zn 62.7- 102.5 ppm in rice plant under effluent treatment. As higher content of Zn (>50.0 ppm) in plant / crops is toxic, precaution should be taken for the consumption of edible parts of plants / crops being grown in the surrounding villages of Vapi industrial belt. Pb was detected in all the plant / crop samples and varied widely from 0.09 to 5.13 ppm with a mean value 2.51 ppm (Table 6). The lowest and the highest value of Pb content were recorded in Caster and Indian bean plant samples from Vatar and Salvav village. In most of the plant / crop samples, Pb content was reasonably high, though soils and water sources were generally low in Pb. Miclean *et al*. (2000) obtained 108-397 mg/kg of Pb in plant in a mining area from Romania and Abii (2012) found 25.85 to 38.83 mg/kg Pb in plants within mechanical workshops in Umuahia. However, plant samples collected from nineteen villages namely, Namdha (100m), Chandor (200m) Cheeri, Kachigam, Dabhel (600m), Patlara, Varkund, Nahuli (700m), Morai, Salvav (800m), Pali, Motidaman (900m) and Nanidaman, Tarakpardi, Barvadi, Sarodhi, Kocharva, Karvad, Valvada (1000m) exhibited Pb content above the maximum permissible limit (2.5 ppm) (Table 7).

cientists reported that above safe concentration (>1.5 ppm) of Pb, it could be risky for human consumption as that might cause brittle bones and weakness in the wrists and fingers and also cause musculoskeletal, renal, ocular, immunological, neurological, reproductive and developmental effects (ATSDR, 1994). As higher content of Pb (>2.5 ppm) in plant / crops might also cause its translocation to the edible part making them harmful and / or toxic for human consumption, precaution must be taken (as of now) for the consumption of edible parts of plants / crops being grown in the above nineteen villages.

All the thirty four plants / crop samples was found to contain Co which varied widely from 7.00 to 44.20 ppm with a mean value 11.26 ppm (Table 6). The highest value of Co (44.20 ppm) was registered in Mango plant sample at village Valvada (1000m distance), while the lowest one (7.00 ppm) was recorded under multiple plants / crop samples like, Sapota, Lemon, Mango, Guava, Cauliflower, Indian bean, Sugarcane, Cabbage, Pigeon pea, Castor, Brinjal, Chilli collected from various villages. Slightly high Co content in almost all plant/ crop samples were possibly due to high Co content in almost all the soils coupled with Co- contaminated water sources. However, Co content of all the samples was well within the permissible limit (50 ppm) (Table 7).

As overdose of Co might lead to angina, asthma, cardiomyopathy, polycythemia and dermatitis. Considering its safety limit (0.05 to 1 mg/day) for human consumption (ATSDR, 1994), precaution should be taken for the consumption of edible parts of plants / crops being grown in the surrounding villages of Vapi industrial belt. Only in fourteen plant / crop samples (in villages situated at 900 and 1000m distance from Vapi industrial belt) Ni was detected which varied appreciably from 3.80 (in Chilli at Tukvada village) to 38.80 ppm (in Mango at Rata and in Brinjal at Kocharva village) (Table 6) and belonged to the category of above maximum permissible limit (1.5 ppm) (Table 7). Malik *et al*. (2010) recorded 41.4 to 59.3 mg/kg Ni in wild plant species from Islamabad, Pakistan, and Bhattacharya *et al*. (2011) obtained 57 to 71 mg/kg of Ni in street and leaf deposited dust in Anand city, India. Ni content >1.5 ppm in Plant / crops might cause its translocation to the edible part making them harmful and / or toxic for human consumption. Considering the safety limit for human consumption of Ni (3 to 7 mg/day in human, ATSDR, 1994) precaution should be taken for the consumption of edible parts of plants / crops being grown in fourteen villages situated at 900 and 1000m distances from the Vapi industrial belt as excess intake might lead to hypoglycemia, asthma, nausea, headache, and epidemiological symptoms. Cd was detected only in seven plant / crop samples at villages situated at 600, 700, 900 and 1000 m distances from Vapi industrial belt where it varied from 0.60 (in sugarcane at Dabhel village) to 13.00 ppm (in Mango at Valvada village) (Table 6). In all the seven plant samples, Cd content were above maximum permissible limit (1.5 ppm) which might be due to uptake of Cd from contaminated soils or water sources or both (Table 7). Considering the safety limit for human consumption of Cd, precaution should be taken for the consumption of edible parts of plants / crops being grown in villages situated at 600, 700, 900 and 1000m distances from the Vapi industrial belt. Miclean *et al*. (2000) obtained 0.48 to 3.12 mg/kg of Cd in plant in a mining area from Romania, Abii (2012) found 4.65 to 6.65 mg/kg Cd in plants within mechanical workshops in Umuahia. Cd content >1.5 ppm in Plant / crops might cause toxic effect as acute doses (10-30 mg/kg/day) of cadmium might cause gastrointestinal irritation, vomiting, diarrhea etc. (ATSDR, 1994). Thus, precaution should be taken for the consumption of edible parts of plants / crops being grown particularly in villages situated at 600, 700, 900 and 1000m distances from the Vapi industrial belt.

CONCLUSIONS

About 48, 100, 6 and 6% soils being deficient to marginal status in respect to DTPA-extractable Fe, Mn, Cu and Zn respectively necessitate improvement of their status through addition of organic manure. BOD and COD of all the water sources are above prescribed limit while. Fe, Mn, Cu, Zn, Ni and Cd were detected only in a few water sources and Pb & Co were found in all sources and were found within maximum permissible limit and are safe. Precaution should be taken for the consumption of edible parts of plants / crops being grown in the surrounding villages of industrial belt, Vapi as all, five, nine, nineteen, fourteen and six number of plant / crop samples were noted to cross maximum permissible limit respectively for Fe, Cu, Zn, Pb, Ni and Cd and as a result might become toxic and or harmful for human consumption leading to various kinds of ailments / diseases and problems.

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Table 1: Name of Village, Distance and Details of Soil, Water and Plant/Crop Samples

Sr. No.	Name of Villages	Distance From Vapi Industrial Belt (M)	Soil Samples	Water Samples and Source	Plant/Crop Samples and Source
1.	Namdha	100	Yes	Borewell	Sapota
2.	Chandor	200	"	Borewell	Lemon
3.	Mohangam	500	"	Borewell	Mango
4.	Palset	600	"	Nil	Guava
5.	Jamburi		"	Well	Jackfruit
6.	Perera		"	Khadi	Nil
7.	Ranginvada		"	Borewell	Sapota
8.	Kachigam		"	Borewell	Cauliflower
9.	Chiri		"	Borewell	Sapota
10.	Zari		"	Nill	India bean
11.	Charvada		"	Borewell	Nil
12.	Dabhel		"	Khadi	Sugarcane
13.	Eklaher	700	"	Borewell	Sugarcane
14.	Patlara		"	Borewell	Cabbage
15.	Aambavadi		"	Well	Cashew nut
16.	Varkund		"	Borewell	Pigeon –pea
17.	Nahuli		"	Borewell	Indian bean
18.	Khadivad	800	"	Borewell	Nil
19.	Kunta		"	Nil	Nil
20.	Vatar		"	Nil	Castor
21.	Morai		"	Nil	Sapota
22.	Salvav		"	Borewell	Indian bean
23.	Palikanadu		"	Nil	Nil
24.	Pali		"	Nil	Brinjal
25.	Bhairi		"	Nil	Nil
26.	Motidaman	900	"	Khadi	Tomato
27.	Tukvada		"	Khadi	Chilli
28.	Rata		"	Khadi	Mango
29.	Dungra		"	Well	Mango
30.	Dadra		"	Borewell	Nil
31.	Palikarambeli	1000	"	Nil	Pigeon-pea
32.	Dholar		"	Borewell	Nil
33.	Nanidaman		"	Borewell	Mango
34.	Tarakpardi		"	Nil	Sugarcane
35.	Bagvada		"	Nil	Nil
36.	Barvadi		"	Khadi	Mango
37.	Sarodhi		"	Borewell	Mango
38.	Velvagad		"	Borewell	Nil
39.	Kocharva		"	Well	Brinjal
40.	Bhatkurvad		"	Borewell	Nil
41.	Degam		"	Nil	Indian bean
42.	Kraya		"	Nil	Mango
43.	Nanitambadi		"	Borewell	Mango
44.	Karvad		"	Lake	Mango
45.	Valvada		"	Borewell	Mango
46.	Vatar		"	Nil	Nil

Table 2: $Ph_{2.5}$, $Ec_{2.5}$ and Dtpa - Extracted Fe, Mn, Cu, Zn, Pb, Co, Ni and Cd of Surface Soils of Different Villages in Surrounding Area of Vapi Industrial Belt

Name of Village.	Distance	$pH_{1:2.5}$	$EC_{1:2.5}$ dS/m	DTPA - Extracted (ppm)							
				Fe	Mn	Zn	Cu	Pb	Co	Cd	Ni
Namdha	**100 m**	8.0	0.11	7.21	4.56	8.09	1.23	2.00	8.92	4.45	0.00
Chandor	**200 m**	8.0	0.06	3.26	4.12	3.09	0.08	0.96	8.28	4.02	0.00
ohangam	**500 m**	6.8	0.16	3.78	3.81	6.08	4.27	0.96	8.76	3.04	0.00
Balitha	**600 m**	7.7	0.25	4.12	3.47	5.75	3.10	0.61	8.60	5.43	0.00
Palset		6.5	0.06	3.78	3.18	6.01	2.94	1.65	8.76	3.75	0.00
Jamburi		6.6	0.09	0.52	2.93	8.82	4.14	2.35	8.60	2.77	0.00
Perera		6.5	0.51	1.12	7.06	4.95	3.01	3.39	9.24	5.70	0.00
Ranginvada		7.6	0.21	3.61	6.87	4.32	6.20	2.35	9.72	3.24	0.00
Kachigam		7.6	0.28	13.30	6.54	4.26	2.25	1.30	12.44	3.83	0.00
Chiri		8.3	0.14	7.98	6.21	9.04	0.55	3.04	9.08	4.77	0.00
Zari		6.6	0.55	8.15	5.84	0.58	3.71	4.78	9.56	2.34	0.00
Charvada		7.9	0.16	9.36	5.32	3.57	2.48	2.00	12.44	3.08	0.00
Dabhel		7.7	0.12	8.58	4.83	2.52	2.65	1.30	7.16	2.30	0.04
Mean		7.30	0.24	6.05	4.55	4.98	3.10	2.28	9.56	3.72	0.05
Eklaher	**700 m**	8.3	0.15	10.04	5.43	0.60	2.17	0.96	12.60	4.73	0.02
Patlara		6.8	0.06	4.12	5.12	3.91	5.06	0.96	12.28	4.33	0.02
Aambavadi		6.8	0.10	6.18	7.79	2.27	5.58	1.65	11.32	3.75	0.04
Varkund		7.9	0.53	19.74	7.41	1.77	7.77	2.70	8.76	4.77	0.02
Nahuli		8.3	0.20	8.07	7.10	0.41	7.19	1.65	5.56	3.28	0.00
Mean		7.62	0.21	9.62	6.75	0.90	5.55	0.79	5.05	2.09	0.00
Khadivad	**800 m**	8.1	0.25	22.67	6.36	3.01	5.06	0.43	9.40	2.77	0.00
Kunta		7.4	0.18	17.43	7.84	4.89	6.51	0.26	4.28	2.22	0.00
Vatar		8.3	0.15	24.13	7.44	3.09	6.19	0.43	5.24	1.28	0.00
Morai		7.4	0.12	7.90	6.96	8.99	7.63	1.48	10.36	3.40	0.05
Salvav		7.6	0.25	54.33	6.52	0.26	7.08	0.09	9.40	2.73	0.05
Mean		7.76	0.19	12.65	6.13	2.02	3.25	0.27	3.87	1.24	0.02
Palikanadu	**900 m**	7.9	0.22	51.85	5.92	7.09	9.96	1.65	8.44	3.67	0.07
Pali		7.6	0.12	55.19	5.45	22.15	9.05	2.70	13.56	4.96	0.03
Bhairi		7.5	0.09	16.40	5.12	8.91	5.04	1.30	11.96	2.89	0.07
Motidaman		7.0	0.53	5.41	4.84	8.74	9.72	3.39	11.96	5.67	0.05
Tukvada		6.8	0.11	34.10	4.51	1.64	7.28	3.39	15.32	3.82	0.03
Rata		7.9	0.10	10.99	4.27	4.60	10.23	5.13	8.12	2.42	0.03
Dungra		7.4	0.14	20.87	3.94	11.40	5.02	8.26	13.24	4.57	0.03
Dadra		8.3	0.25	30.31	4.56	0.19	8.14	0.09	5.88	1.24	0.02
Mean		7.5	0.20	28.14	4.12	8.09	6.44	2.59	8.85	2.92	0.04
Palikarambeli	**1000 m**	7.1	0.30	20.87	5.84	7.33	8.81	1.13	13.08	3.08	0.01
Dholar		7.0	0.14	30.31	6.17	6.27	10.42	0.26	11.16	4.14	0.01
Nanidaman		7.8	0.17	20.95	6.91	10.57	6.11	2.17	8.92	3.36	0.00
Tarakpardi		7.1	0.39	9.10	4.26	2.05	7.15	1.83	5.08	1.28	0.00
Bagvada		7.7	0.28	26.09	3.99	6.44	10.47	2.17	6.84	1.71	0.02
Barvadi		7.8	0.42	10.04	3.53	5.32	7.39	1.48	5.72	1.59	0.00
Sarodhi		8.1	0.34	4.89	2.69	6.83	8.79	1.13	11.48	1.87	0.00
Velvagad		7.9	0.28	6.95	7.16	9.75	7.77	1.48	8.44	1.47	0.02
Kocharva		8.0	0.23	18.45	7.41	5.19	8.70	2.87	12.28	2.26	0.02
Bhatkurvad		7.7	0.21	7.21	7.72	5.69	7.96	2.00	10.36	2.10	0.03
Degam		7.6	0.28	24.87	4.10	1.53	8.66	2.17	12.28	1.99	0.07
Karaya		7.0	0.05	13.39	4.33	1.74	9.96	1.13	15.16	1.67	0.03
Nanitambadi		8.1	0.24	7.26	4.83	3.74	2.96	1.83	14.84	1.67	0.05
Karvad		8.3	0.16	11.31	5.11	3.03	4.83	0.43	9.56	1.95	0.09
Valvada		7.2	1.21	13.20	5.46	5.24	7.36	1.43	11.99	1.02	0.07
Mean		7.63	0.31	15.92	5.30	5.38	7.82	1.57	10.48	2.08	0.03

Table 3: Categorization of Dtpa- Extracted Fe, Mn, Zn and Cu in Soils as Based on Deficient, Marginal, and Adequate Level

Distance (Number of Samples)	Number of Soil Samples Under Different Classes											
	Iron (Fe) ppm			Manganese (Mn) ppm			Zinc (Zn) ppm			Copper (Cu) ppm		
	D <5	M 5 to 10	A >10	D <5	M 5 to 10	A >10	D <0.5	M 0.5 to 1.0	A >1.0	D <0.2	M 0.2 to 0.4	A >0.4
100 m (1)	-	1	-	1	-	-	1	-	-	-	-	
200 m (1)	1	-	-	1	-	-	1	-	-	-	-	1
500 m (1)	1	-	-	-	1	-	-	-	1	-	-	1
600 m (10)	5	4	1	4	6	-	-	1	9	-	-	10
700 m (5)	1	2	2	-	5	-	-	-	5	-	-	5
800 m (5)	-	1	4	-	5	-	-	-	5	-	1	4
900 m (8)	-	1	7	5	3	-	-	-	8	-	-	8
1000 m (15)	1	4	10	7	8	-	-	-	15	-	-	15
Total	**9**	**13**	**24**	**18**	**28**	**0**	**2**	**1**	**43**	**1**	**1**	**44**

D: Deficient, M: Marginal, A: Adequate

Table 4: Ph, Ec, Bod, Cod and Content of Fe, Mn, Cu, Zn, Pb, Co, Ni, Cd, in Major Water Sources From Surrounding Villages of Vapi Industrial Belt

Distance & Name of Village.	PH	EC (dSm^{-1})	Saline Alkaline class	BOD (mg/L)	COD (mg/L)	Fe	Mn	Cu	Zn	Pb	Co	Ni	Cd
						(ppm)							
100 m													
Namdha	6.35	0.38	C_2	79.2	264	ND	ND	ND	0.006	0.227	0.003	ND	ND
200 m													
Chandor	7.32	0.73	C_2	84.0	280	ND	ND	ND	ND	0.013	0.003	ND	ND
500 m													
Mohangam	6.80	0.60	C_2	93.6	312	ND	ND	ND	ND	0.547	0.003	ND	ND
600 m													
Jamburi	6.31	0.13	C_1	76.8	256	ND	ND	ND	ND	0.013	0.003	ND	ND
Perera	7.18	0.77	C_3	72.0	240	ND	ND	ND	ND	0.013	0.003	ND	ND
Ranginvada	7.40	0.50	C_2	82.2	274	ND	ND	ND	ND	0.013	0.003	ND	ND
Kachigam	7.42	0.47	C_2	74.3	264	ND	ND	ND	0.002	0.120	0.003	ND	ND
Chiri	7.27	0.27	C_2	75.7	240	ND	ND	ND	ND	0.013	0.003	ND	ND
Charvada	6.75	0.28	C_2	76.8	274	ND	ND	ND	ND	0.013	0.003	0.000	0.002
Dabhel	7.03	1.11	C_3	79.2	256	ND	ND	ND	ND	0.013	0.003	0.015	ND
Mean	7.05	0.50	C_2	76.7	257	ND	ND	ND	ND	0.028	0.003	0.002	ND
700 m													
Eklaher	7.68	1.95	C_3	72.2	248	ND	ND	ND	ND	0.120	0.003	ND	ND
Patlara	7.19	0.23	C_1	64.3	284	ND	ND	ND	ND	0.013	0.003	ND	ND
Aambavadi	7.57	0.48	C_2	74.4	274	ND	ND	ND	ND	0.013	0.003	ND	0.002
Varkund	7.61	1.02	C_3	82.2	240	0.022	ND	ND	ND	0.013	0.003	ND	0.018
Nahuli	7.38	0.95	C_3	79.2	304	ND	ND	0.003	ND	0.440	0.003	ND	0.005
Mean	7.49	0.93	C_3	74.5	270	0.004	ND	ND	ND	0.119	0.003	ND	0.005
800 m													
Khadivad	8.06	0.67	C_2	76.2	256	ND	ND	0.083	ND	0.120	0.003	ND	0.015
Salvav	7.31	1.52	C_3	74.3	176	ND	ND	ND	ND	0.120	0.003	ND	0.021
Mean	7.69	1.10	C_3	75.3	216	ND	ND	0.041	ND	0.12	0.003	ND	0.018
900 m													
Motidaman	7.63	0.46	C_2	61.2	168	ND	ND	ND	ND	0.227	0.003	ND	0.021
Tukvada	7.33	0.26	C_2	71.5	144	ND	ND	ND	ND	0.440	0.003	ND	ND
Rata	7.43	0.22	C_1	77.6	136	ND	0.014	ND	ND	0.440	0.043	ND	ND
Dungra	7.54	0.36	C_2	75.6	152	ND	ND	ND	ND	0.440	0.003	ND	ND
Dadra	7.48	0.20	C_1	65.9	176	ND	ND	ND	ND	0.013	0.003	ND	0.002
Mean	7.48	0.30	C_1	70.3	155	ND	0.002	ND	ND	0.312	0.011	ND	0.004
1000 m													
Dholar	7.96	0.51	C_2	71.30	144.00	ND	ND	ND	ND	0.013	0.003	ND	ND
Nanidaman	7.07	0.19	C_1	64.80	136.00	ND	ND	ND	ND	0.013	0.003	ND	0.008
Barvadi	7.46	0.23	C_1	82.30	195.00	ND	ND	ND	ND	0.013	0.003	ND	ND
Sarodhi	7.90	0.76	C_3	79.20	245.00	ND	ND	ND	ND	0.013	0.003	ND	0.005

Table 4: Contd.,

Velvagad	7.39	0.56	C_2	76.30	183.00	ND	ND	ND	0.002	0.013	0.003	ND	0.008
Kocharva	7.93	1.03	C_3	84.00	221.00	ND	ND	ND	ND	0.013	0.003	ND	0.002
Bhatkurvad	7.81	1.04	C_3	65.30	175.00	ND	ND	ND	ND	0.013	0.003	ND	0.008
Nanitambadi	6.74	1.02	C_3	47.40	224.00	ND	ND	ND	0.021	0.120	0.003	ND	0.002
Karvad	7.48	0.28	C_2	77.50	173.00	ND	0.025	ND	0.002	0.013	0.003	ND	ND
Valvada	7.14	0.36	C_2	64.80	168.00	ND	ND	ND	0.017	0.120	0.023	ND	ND
Mean	7.49	0.60	C_2	71.29	186.40	ND	0.002	ND	0.004	0.034	0.005	ND	0.003

ND - not detected

Table 5: Categorization of Water Sources as Based on Maximum Permissible Limit of Toxic Metals in Water (Ppm)

Distance of Water Sources (Number of Samples).	Iron (fe) Mpl 0.3 (mgl^{-1})		Manganese (mn) Mpl 0.05 (mgl^{-1})		Copper (cu) Mpl 0.05 (mgl^{-1})		Zinc (zn) Mpl 5.0 (mgl^{-1})		Lead (pb) Mpl 0.1 (mgl^{-1})		Cobalt (co) Mpl 0.05 to 1.5 (mgl^{-1})		Nickel (ni) 0.02 (mgl^{-1})		Cadmium (cd) 0.01 (mgl^{-1})	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
100 m (1)	1	-	1	-	1	-	1	-	-	1	1	-	1	-	1	-
200 m (1)	1	-	1	-	1	-	1	-	1	-	1	-	1	-	1	-
500 m (1)	1	-	1	-	1	-	1	-	-	1	1	-	1	-	1	-
600 m (7)	7	-	7	-	7	-	7	-	6	1	7	-	7	-	7	-
700 m (5)	5	-	5	-	5	-	5	-	3	2	5	-	5	-	5	-
800 m (2)	2	-	2	-	2	-	2	-	-	2	2	-	2	-	-	2
900 m (5)	5	-	5	-	5	-	5	-	1	4	5	-	5	-	4	1
1000 m (10)	10	-	10	-	10	-	10	-	8	2	10	-	10	-	10	-
Total	**32**	**-**	**32**	**-**	**32**	**-**	**32**	**-**	**19**	**13**	**32**	**-**	**32**	**-**	**29**	**3**

B: below and A: Above

MPL: maximum permissible limit (WHO)

Table 6: Total Content of Fe, Mn, Cu, Zn, Pb, Co, Ni and Cd in Some Plant / Crop Samples from Different Villages in Surrounding Area of Vapi Industrial Belt

Distance & Name of Village.	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Pb (ppm)	Co (ppm)	Ni (ppm)	Cd (ppm)
100 m								
Namdha	1600.0	60.6	16.6	40.2	3.70	7.00	ND	ND
200 m								
Chandor	538.8	18.0	9.2	12.8	3.90	7.00	ND	ND
500 m							ND	ND
Mohangam	748.4	47.4	33.2	32.8	2.36	7.00	ND	ND
600 m								
Palset	681.4	52.4	9.2	67.6	0.22	7.00	ND	ND
Jamburi	ND	47.4	25.8	68.4	2.12	16.20	ND	ND
Ranginvada	634.0	72.0	13.0	65.0	1.69	7.00	ND	ND
Kachigam	1821.2	142.0	9.2	25.4	3.69	7.00	ND	ND
Chiri	476.8	11.4	22.2	81.8	2.89	7.00	ND	ND
Zari	157.4	21.2	16.6	18.0	1.66	7.00	ND	ND
Dabhel	1702.0	175.2	14.8	21.4	3.41	7.00	ND	0.60
Mean	7514.8	74.5	15.8	354.6	2.24	8.31	ND	0.09
700 m								
Eklaher	1678.2	67.0	11.0	68.4	1.65	7.00	ND	0.00
Patlara	596.0	9.8	18.4	18.8	2.70	7.00	ND	6.40
Aambavadi	119.2	8.2	24.0	103.8	1.30	16.20	ND	7.20
Varkund	309.8	40.8	25.8	5.4	3.39	7.00	ND	ND

Table 6: Contd.,

Nahuli	529.2	45.6	14.8	57.0	3.39	7.00	ND	ND
Mean	646.4	50.7	18.8	50.6	2.49	8.84	ND	2.72
800 m								
Vatar Morai Salvav	190.6	50.8	9.2	15.4	0.09	7.00	ND	ND
	486.2	18.0	20.2	20.0	2.59	7.00	ND	ND
	572.0	65.4	14.8	45.6	5.13	7.00	ND	ND
Mean	416.2	58.4	14.7	27	2.60	7.00	ND	ND
900 m								
Pali Motidaman Tukvada Rata Dungra	181.2	31.0	13.0	18.0	4.23	7.00	ND	ND
	233.6	86.8	35.0	28.2	3.12	16.20	23.20	ND
	1903.0	14.6	13.0	8.8	2.14	7.00	3.80	3.00
	181.2	121.2	35.0	55.6	1.12	7.20	38.80	8.80
	839.0	62.2	13.0	6.6	1.54	7.00	27.20	ND
Mean	667.6	63.1	21.8	23.4	2.43	8.88	18.60	2.36
1000m								
Palikarambeli Nanidaman Tarakpardi Barvadi Sarodhi Kocharva Degam Karaya Nanitambadi Karvad Valvada	290.8	ND	11.0	12.0	1.11	16.20	15.60	ND
	66.8	54.0	9.2	16.8	2.54	25.60	15.60	ND
	290.8	21.2	7.4	3.4	3.22	7.00	3.80	ND
	181.2	91.6	13.0	12.0	2.80	7.00	15.60	ND
	352.8	78.6	20.2	24.2	3.80	16.20	3.80	ND
	629.4	126.0	35.0	93.8	2.65	34.80	38.80	7.20
	929.6	74.2	13.0	23.4	2.32	7.00	7.80	ND
	867.6	39.2	74.0	10.0	1.22	7.00	3.80	ND
	290.8	37.6	13.0	33.4	1.02	7.00	ND	ND
	977.4	34.4	14.8	8.0	3.62	7.00	3.80	ND
	433.8	108.0	18.4	39.6	3.22	44.20	3.80	13.00
Mean	482.8	58.9	20.8	25.1	2.50	16.27	10.21	1.84

ND: Not detected

Table 7: Categorization of Toxic Metals in Plant Samples as Based on Maximum Permissible Limit (ppm)

Distance of soil sources from Vapi IC (number of samples).	Iron (Fe) MPL 5.0 (mgkg^{-1})		Copper (Cu) MPL 30.0* (mgkg^{-1})		Zinc (Zn) MPL 50.0* (mgkg^{-1})		Lead (Pb) MPL 2.5* (mgkg^{-1})		Cobalt (Co) MPL 50 (mgkg^{-1})		Nickel (Ni) MPL 1.5*, (mgkg^{-1})		Cadmium (Cd) MPL 1.5*(mgkg^{-1})	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A
100 m (1)	-	1	1	-	1	-	-	1	1	-	1 ND	-	1 ND	-
200 m (1)	-	1	1	-	1	-	-	1	1	-	1 ND	-	1ND	-
500 m (1)	-	1	-	1	1	-	1	-	1	-	1 ND	-	1ND	-
600 m (7)	1 (Nd)	6	7	-	3	4	4	3	7	-	1 ND+ 6	-	6 ND+1	-
700 m (5)	-	5	5	-	2	3	2	3	5	-	1 ND + 4	-	3ND	2
800 m (3)	-	3	3	-	3	-	1	2	3	-	1 ND + 3	-	3 ND	-
900 m (5)	-	5	3	2	4	1	3	2	5	-	-	1 ND + 4	3 ND	2
1000 m (11)	-	11	8	3	10	1	4	7	11	-	-	1 ND +10	9 ND	2
Total	1	33	29	6	25	9	15	19	34	-	20	14	28	6

B: Below and A: Above, ND: not detected,

MPL= maximum permissible limit as based on WHO/FAO and

* denote as based on Indian standard