TITLE OF THE PROJECT

SOME STUDIES OF HEAVY METALS IN VEGETABLES IN NAVI MUMBAI INDUSTRIAL AREA MAHARASHTRA

FINAL PROJECT REPORT

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2.10 Monika Kharub *et al*., 2012

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ABSTRACT

Study Area

Navi Mumbai, formerly known as New Bombay, is a city on the west coast of the Indian state of Maharashtra. It was developed in 1972 as a twin city of Mumbai, and is one of the largest planned cities in the world, with a total area of 344 km^2 and 163 km^2. Navi Mumbai lies on the mainland on the eastern seaboard of Thane Creek and spreads over parts of two districts of Maharashtra; Thane, and Raigad. The region is hilly in some parts, and certain areas of the region are protected wetlands. Navi Mumbai is a part of South Konkan coast line. This coastal line joins Sahyadri mountain ranges to the south and 50 to 100 m high hills to the east. Thus the Navi Mumbai area lies between mountain ranges and a coast line. The most developed areas of Navi Mumbai are Vashi is the queen of Navi Mumbai. Has been selected for the case study since numerous sources emit trace metals including several major and minor industries located near the city. Majority of industries such as refineries, chemicals fertilizers are located in MIDC.the vegetables are cultivated in a close proximity to the emission sources of trace metals.

Sample Collection

Samples were collected from sector 26 Airoli Navi Mumbai in the year 2013, These farmland were chosen for this study mainly because the vegetables harvested from these farmlands are supplied to the residents in these areas and also marketed to the nearby markets for public consumption. Vegetable samples including Kardai, Red

Mat, Spinach, and Mayalu were collected from plots and samples were harvested in a 1m x1 m quadrant. Vegetables were handpicked using vinyl gloves and carefully packed into polyethylene bags. Only the edible parts of each vegetable were used for analysis. In addition, soil samples were collected from the sites form where the vegetables were taken. Vegetable samples were divided into two sub-samples; one sub-sample was thoroughly washed several times with tap water followed by distilled water to remove dust particles and the second sub-sample was left untreated. All vegetable samples were oven dried at 80°C for 24 hrs.

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CHAPTER 1

INTRODUCTION

Heavy metals are significant environmental pollutants; and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons. The term ‘‘heavy metals’’ refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech Water Treatment and Air Purification 2004). ‘‘Heavy metals’’ in a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm3, or 5 times or more, greater than water (Hawkes 1997). However, chemical properties of the heavy metals are the most influencing factors compared to their density. Heavy metals include lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr), iron (Fe), arsenic (As), silver (Ag) and the platinum group elements. Heavy metal which causes objectionable effects, impairing the welfare of the environment, reducing the quality of life and may eventually cause death. Such a substance has to be present in the environment beyond a sector tolerance limit. which may be poisonous or toxic and will cause harm to living things in the polluted environment. Heavy metals are largely found in dispersed form in rock formations. Industrialization and urbanization have increased the anthropogenic contribution of heavy metals in biosphere. Heavy metals have largest availability in soil and aquatic ecosystems and to a relatively smaller proportion in atmosphere as particulate or vapors. Heavy metal toxicity in plants varies with plant species, specific metal, concentration, chemical form and soil composition and pH, as many heavy metals are considered to be essential for plant growth. Some of these heavy metals like Cu and Zn either serve as cofactor and activators of enzyme reactions (Mildvan 1970) or exert a catalytic property such as prosthetic group in metalloproteins. These essential trace metal nutrients take part in redox reactions, electron transfer and structural functions in nucleic acid metabolism. Some of the heavy metal such as Cd, Hg and As are strongly poisonous to metal-sensitive enzymes, resulting in growth inhibition and death of organisms. An alternative classification of metals based on their coordination chemistry, heavy metals that come under non-essential trace elements, which are highly toxic elements such as Hg, Ag, Pb, Ni (Nieboer and Richardson 1980). Some of these heavy metals are bio-accumulative, and they neither break down in the environment nor easily metabolized. Such metals accumulate in ecological food chain through uptake at primary producer level and then through consumption at consumer levels. Plants are stationary, and roots of a plant are the primary contact site for heavy metal ions. In aquatic systems, whole plant body is exposed to these ions. Heavy metals are also absorbed directly to the leaves due to particles deposited on the foliar surfaces.

Heavy metal emission

Heavy metals can be emitted into the environment by both natural and anthropogenic activities. The major causes of emission are the anthropogenic sources specifically mining operations (Nriagu 1989). In some cases, even long after the mining activities have ceased, the emitted metals continue to persist in the environment. Peplow (1999) reported that hard rock mines operate from 5–15 years until the minerals are depleted, but metal contamination that occurs as a consequence of hard rock mining persist for hundreds of years after the cessation of mining operations. Apart from mining operations, mercury is introduced to the environment through cosmetic products as well as manufacturing processes like making of sodium hydroxide. Heavy metals are emitted both in elemental and in compound (organic and inorganic) forms. Anthropogenic sources of emission are the various industrial point sources including former and present mining sites, foundries and smelters, combustion by-products and traffics (UNEP/GPA 2004). Cadmium is released as a by-product of zinc (and occasionally lead) refining; lead is emitted during its mining and smelting activities, from automobile exhausts (by combustion of petroleum fuels treated with tetraethyl lead antiknock) and from old lead paints; mercury is emitted by the degassing of the earth's crust. Generally, metals are emitted during their mining and processing activities (Lenntech Water Treatment and Air Purification 2004). Environmental pollution by heavy metals is very prominent in areas of mining, and old mine sites and pollution reduces with increasing distance away from mining sites (Peplow 1999). These metals are leached out and in sloppy areas are carried by acid water downstream or run off to the sea. Through mining activities, water bodies are most emphatically polluted (Garbarino et al. 1995; INECAR 2000). The potential for contamination is increased when mining exposes metal-bearing ores rather than natural exposure of ore bodies through erosion (Garbarino et al. 1995), and when mined ores are dumped on the earth surfaces in manual decreasing processes. Through rivers and streams, the metals are transported as either dissolved species in water or an integral part of suspended sediments,(dissolved species in water have the greatest potential of causing the most deleterious ffects). They may then be stored in river bed sediments or seep into the underground water thereby contaminating water from underground sources, particularly wells, and the extent of contamination will depend on the nearness of the well to the mining site. Wells located near mining sites have been reported to contain heavy metals at levels that exceed drinking water criteria (Garbarino et al. 1995; Peplow 1999).

1:1Sources of contamination

There are different sources of heavy metals in the environment such as

(1) Natural sources,

(2) Agricultural sources,

(3) Industrial sources,

(4) Domestic effluent,

(5) Atmospheric sources and

(6) Other sources.

1:2 Natural sources of heavy metals

The most important natural source of heavy metals is geologic parent material or rock outcroppings. The composition and concentration of heavy metals depend on the rock type and environmental conditions, activating the weathering process. The geologic plant materials generally have high concentrations of Pb, Mn, Zn, Cr, As, Cu, Ni, & Fe. However, class-wise the heavy metal Concentrations vary with in the rocks. Soil formation takes place mostly from sedimentary rock, but is only a small source of heavy metals, since it is not generally or easily weathered. However, many igneous rocks such as olivine, augite and hornblende contribute considerable amounts of Mn, Co, Ni, Cu and Zn to the soils. Within the class of sedimentary rocks, shale has highest Concentrations of Cr, Mn, Co, Ni, Cu, Zn, Cd, Sn, Hg and Pb followed by limestone and sand stone. Volcanoes have been reported to emit high levels of Al, Zn, Mn, Pb, Ni, Cu and Hg along with toxic and harmful gases (Seaward and Richardson 1990). Wind-blown dusts and volcanic eruptions are of particulate relevance to ecosystem inventories and budgets of heavy metals. Wind dust, Marine aerosols and forest fires also exert a major influence in the transport of some heavy metals in many environments.

1:3Agricultural sources of heavy metals

The inorganic and organic fertilizers (Fertilizer is a substance added to soil to improve plants growth and yield.)Are the most important sources of heavy metals to agricultural soil include liming, sewage sludge, irrigation waters and pesticides, sources of heavy metals in the agricultural soils, Others, particularly fungicides, inorganic fertilizers and phosphate fertilizers have variable levels of Cd, Cr, Ni, Pb and Zn depending on their sources. Cadmium is of particular concern in plants since it accumulates in leaves at very high levels, which may be consumed by animals or human being. Cadmium enrichment also occurs due to the application of sewage sludge, manure and limes (Nriagu 1988; Yanqun et al. 2005). Although the levels of heavy metals in agricultural soil are very small, but repeated use of phosphate fertilizer and the long persistence, time for metals, there may be dangerously high accumulation of some metals (Verkleji 1993).Animal manure enriches the soil by the addition of Mn,Zn, Cu and Co and sewage sludge by Zn, Cr, Pb, Ni, Cdand Cu (Verkleji 1993). The increase in heavy metal contamination of agricultural soil depends on the rate of application of the contributors with its elemental concentration and soil characteristics to which it is applied. Heavy metal accumulation in soil is also due to application of soil amendments such as compost refusing and nitrate fertilizers (Ross 1994). Liming increases the heavy metal levels in the soil more than the nitrate fertilizers and compost refuse. Sewage sludge is one of the most important sources of heavy metal contamination to the soil (Ross 1994) Several heavy metal–based pesticides (Pesticides kill unwanted pests) are used to control the diseases of grain and fruit crops and vegetables and are sources of heavy metal pollution to the soil (Verkleji 1993; Ross 1994). Continued irrigation of agricultural soil can lead to accumulation of heavy metals such as Pb and Cd. The contamination of soil by heavy metals may also be from irrigation water sources such as deep wells, rivers, lakes or irrigation canals (Ross 1994).

1:4Industrial sources of heavy metals

Industrial sources of heavy metals include mining, refinement (spoil heaps and tailings, transport of ores, smelting and metal finishing and recycling of metals). Mining operation emits different heavy metals depending on the type of mining which enrich the soil around the coalfield directly or indirectly. have become a

Significant source of this pollutant to the environment (Lacerda 1997). High temperature processing of metals such as smelting and castings emit metals in particulate and vapor forms. Vapor form of heavy metals such as As, Cd, Cu, Pb, Sn and Zn combine with water in the atmosphere to form aerosols. These may be either dispersed by wind (dry deposition) or precipitated in rainfall (wet deposition) causing contamination of soil or water bodies. Contamination of soil and water bodies can also occur through runoff from erosion of mine wastes, dusts produced during the transport of crude ores, corrosion of metals and leaching of heavy metals to soil and ground water. Soil contamination of heavy metals occurs due to different types of processing in refineries. Energy supplying power stations such as coal burning power plants, petroleum combustion, nuclear power stations and high tension lines contribute many heavy metals such as Se,B,Cd, Cu,Zn, Cs andNi to the environment (Verkleji 1993). Other industrial sources include processing of plastics, textiles, microelectronics, wood preservation and paper processing.

Contamination of plants growing beneath the power line with high concentration of Cu is reported to be toxic to the grazing animals (Kraal and Ernst 1976).

1:5 **Domestic effluents**

These waste waters probably constitute the largest single source of elevated metal values in rivers and lakes. Domestic effluents may consists of (1) untreated waste waters (2) substances which have passed through the filters of

biological treatment plants (3) waste substances passed over sewage outfalls and discharged to receiving water bodies often end up into the sea from coastal residential areas The use of detergents creates a possible pollution hazard, since common house hold detergent products can affect the water quality. Angino et al. (1970) found that most enzyme detergents contained trace amounts of the elements Fe, Mn, Cr, Co, Zn, Sr and B. With regard to pollution resulting from urbanized areas, there is an increasing awareness that urban runoff presents a serious problem of heavy metal contamination. A statistical summary by Bradford (1997) revealed that urban storm water runoff has long been recognized as a major source of pollutants to surface waters. Studies by Bolter et al. (1974) indicate that lead is leached by humic and other acids, thus increasing its availability for runoff rather than seepage into the upper soil layer.

1:6 Other sources

Other sources of heavy metals include refuse incineration, landfills and transportation (automobiles, diesel-powered vehicles and aircraft). Two main anthropogenic sources that contaminate the soil are fly ash produced due to coal burning and the corrosion of commercial waste products, which add Cr, Cu, Pb and galvanized metals (primarily Zn) into the environment (Al-Hiyaly et al. 1988). Coal burning adds heavy metals such as Cd, Hg, Mn, Ni, Al, Fe and Ti into the soils (Verkleji 1993). Oil burning contributes V,Fe, Pb and Ni to the environment. Metal emission during the transportation of vehicles includes Ni and Zn from tires, Al from catalyst, Cd and Cu primarily from diesel engines and Ni and Zn from aerosol emissions. Lubricants which are antiwear protectants for vehicles emit Cd, Cr, Hg, Ni, Pb and Zn, particularly in case of inefficient engines. The burning of leaded gasoline has been an important source of Pb in the environment. Incinerations of municipal wastes generate significant concentrations of Zn, Pb, Al, Sn, Fe and Cu.

1.7Aim and Objectives:-

1 The objective of the present investigation is to understand the effect of heavy metals on vegetables generated from the different types of industries.

2 To find out the most polluted & less polluted sites.

3 To find out the effect of these metals on ecosystem.

4 Imparting informal and formal public awareness programmes to educate people at large regarding health hazards and undesirable effects due to environmental pollution.

5 To suggest the improvement and possible control measures to reduce heavy metals on the environment.

CHAPTER 2

LITERATURE REVIEW

Krishna *et al.*, 2005 have reported that the pollution caused due to excessive accumulation of heavy metals in soils near Thane-Belapur industrial belt of Mumbai. The soils were enriched with Cu, Cr, Co, Ni and Zn. The study highlight the need for instituting a systematic and continuous monitoring of the study area for heavy metals and other forms of pollution to ensure that pollution does not become a serious problem in future.

Srinivasa *et al.*, 2008 have reported the concentration of lead , nickel, chromium,cadmium, copper and zinc were found to be higher than the normal permissible limits in their study area . The people are seriously affected and suffering from occupational diseases such as asthma, skin diseases.

Govil *et al.*, 2008 have studied the random dumping of hazardous waste in the industrial area is the main cause` of the contaminant spreading by rainwater and wind. In the residential areas the local dumping is expected to be the main source.

Rajesh Kumar *et al.*, 2008 have reported that the sampling locations situated in industrial or commercial areas with heavy traffic load showed significantly elevated levels of copper, zinc and cadmium deposition rate as compared to those situated in residential areas with low traffic load. The deposition rates of these etals were significantly higher in summer and winter as compared to rainy season.

Sezgin Bakirdere *et al.*, 2008 have studied about the lead content of roadside soil decreases with increasing distance from the motorway and there were big differences in the concentration of lead in two sides of road. The magnitude of Cd contamination in soil was generally in the decreasing order of distance from road.

Ganesh Ramdas Bhagure *et al.*, 2010 have reported that the whole of the study areas is heavily contaminated by arsenic, chromium, cadmium, mercury, and cobalt. The level of these metals is above the limit as prescribed (SSQG).

Pradip K *et al*., 2010 studied the distribution of heavy metals in surface water of Ranipet industrial area in Tamil Nadu, India. The results revealed that the surface water in that area is highly contaminated showing very high concentrations of some of the heavy metals like Cd, Cr, Cu, Ni, Pb and Zn. They observed that the people in the area were seriously affected and suffering from occupational diseases such as asthma, chromium ulcers and skin diseases.

Dasaram B *et al*., 2011 reported that the soil is the sink for toxic trace metals in Patancheru industrial area. The Index of geoaccumulation, enrichment and contamination factor invariable shows that the soil from residential area is moderately contaminated with Cr, Ni and Pb. The agricultural soil indicated relatively less contamination indices and it is presumed that plant uptake of these elements along with other macro and micro nutrients during its growth has effectively removed the toxic metals from the soil.

Gandhimathi A *et al*., 2012 have reported that the pollution caused due to improper drainage system, industry effluents, solid wsates and liquid waste being discharged randomly on soil, lake and road side without any treatment. They developed neural networks consist of 2 input neurons, 6 hidden layers consisting of 10 to 20 neurons in each layer for training and 1 neuron to predict the constituents of the heavy metals in soil.

Monika Kharub *et al*., 2012 studied heavy metal (Zn, Cu, Pb, Fe, Cd, Ni, Cr, Co) content in vegetable samples which were randomly collected from market and agricultural fields in and around Fatehabad city(Haryana). They reported that vegetable samples collected from agricultural fields were highly contaminated with Zn, Fe, Cu, Pb and Cd metal ions which can pose serious health hazards to human health.

CHAPTER 3

MATERIALS AND METHODS

3.1 STUDY AREA

Navi Mumbai is world's largest planned city with a horizon of 344 sq kms. It includes an area of 95 villages in it, having a coastal stretch of 34.2 kms along Thane and Panvel creeks. To avoid the haphazard spill over of Mumbai, Plan for Mumbai Metropolitan Region (MMRP) was prepared under the provision of Maharashtra Regional and Town Planning act 1966, which was sanctioned by Goyt in 1973. One of the most important propositions of the sanctioned MMRP was to develop a new metro city in Trans Thane creek and Trans harbor area extending inland up to Panvel and Uran.The new metro city was subsequently named as New Bombay (Now Navi Mumbai). Navi Mumbai comprises of the strip of marshy land lying between village Dighe in Thane district and Kalundre village of Raigad district parallel to the then Greater Bombay. The City & Industrial Development Corporation of Maharashtra Ltd (CIDCO), a Company fully owned by the state Government, was declared as New Town Development Authority under the Provisions of MRTP Act, 1966, to plan and develop the city of Navi Mumbai. For this purpose, the State Govt. notified all the privately owned lands within the notified area of Navi-Mumbai for acquisition under the L.A. Act. The land so acquired by State Government was vested in CIDCO for the development and disposal purpose. CIDCO carved out 08 nodes (small townships) of the land with a view to facilitate comprehensive development and to give it an identity of new city. These nodes are named Airoli, Ghansoli, Kopar Khairane, Vashi, Sanpada, Nerul, CBD Belapur, Digha. As the city grew in size, a need was felt to create an urban local body to take care of day to day maintenance of the city as well as other functions such as public health, primary education etc. which was not the mandate of CIDCO. The Navi Mumbai Municipal Corporation (NMMC) accordingly came into existence on 1st Jan.1992 with its jurisdiction covering 29 villages out of Navi Mumbai project area and another 15 villages from Kalyan complex area (Total of 44 villages from Thane Taluka) with a combined area of 162.5 sq.Km. This area is known as NMMC Area. Subsequently the developed nodes within the jurisdiction of NMMC were transferred by CIDCO to NMMC for maintenance purpose although CIDCO continues to own and develop vacant land within these nodes as the development authority. All the capital and revenue expenditure in these nodes is borne by NMMC.

General Information about Navi Mumbai

3.1.1 Geography:

NMMC area is spread in district of Thane in Maharashtra. It is located in latitudes of 20^0 N 73^O E. It consists of hilly areas and certain parts under wetlands.

3.1.2 Location and Connectivity:

NMMC area lies on the eastern main land of Thane creek. It starts from Digha, Airoli in the north and Nerul Belapur in the south. NMMC area is well connected to Greater Mumbai and other cities like Thane and Pune.. Apart from the decades old Thane creek bridge connecting Mankhurd with Vashi, there are two road bridges and one rail link and third connection via Sewri is proposed by MSRDC. Seven railway stations on Mankhurd Belapur line at different nodes provide full connectivity to NMMC area up to Kurla. Five railway stations on Thane Sanpada line also connect Kalyan via Kalwa. A new international airport is also planned in Navi Mumbai region.

3.1.3 Geology

The rock formation in the region is derived mainly from Deccan Basalt and also from granites, gneisses and laterite. The gently sloping coastal low lands are observed in patches and are covered with moderately shallow to deep soils, mostly lateritic in nature, sometimes oxidized to yellow murrum.

Topography

To part of Western Konkan coast is a narrow coastal strip along the western part of Sahyadris. It is bound on the eastern side by hillocks of height of 50-200 mt. and on the west side by Thane creek.

3.1.4 Climate

This area has sub-tropical monsoonal climate of humid-per-humid to semi-arid and sub humid type. Overall climate is equable with high rainfall days and very few days of extreme temperatures.

3.1.5Temperature

The mean annual temperature ranges from 25C to 28C. The mean maximum temperature of the hottest month in this area varies from 30C - 33C in April-May while mean minimum temperature of coldest month varies from 16C to 20C. Extremes of temperatures, like 38- 39C in summer and 11-14C in winter, may be experienced for a day or two in respective season.

3.1.6 Rainfall

The rainy season is mostly confined to south-west monsoon with 80 percent of the rainfall being received during June to October (60-70 days). This area, on an average, receives 2500 to 3500 mm rainfall

3.1.7 Humidity

The area has marine humid-per humid climate with more humidity and less daily variations. Relative humidity varies from 41 to 97%. Driest days being in winter and wettest ones are experienced in July.

3.1.8 Wind

Features such a presence of large water body (the creek), presence of hill ridges etc. influence the local wind patterns to some extent. No significant micro-climatic variation is noticeable in the region.

3.1.9 Soil

The soil of this area is highly saline in the vicinity of creeks and non-saline at other places. They are calcareous, neutral to alkaline in reaction (pH 7.5 to 8.5), clayey, with high amount of bases and have high water holding capacity (200-250 mm/m). The soils located on moderately sloping residual hills are lateritic in nature and show intensively leached surfaces. They are loamy and slight to moderately acidic (pH 5-6.5) with moderate base status (< 75%).

A detailed break up of land use is given below.

Types of area	**Area in sq.Km**
Urban Area	52.6
MIDC Area	25.6
Village/agriculture	27
Marshy Land	30.75
Forest/sanctuaries	26.55
Total	**162.5**

Source- NNMC

Out of total developed area of 162.50 sq km, 50.79% area is used for urban commercial, industrial, administrative areas and infrastructure such as crematorium, water supply and sewage disposal, roads, railways. 19.92 sq km area is undeveloped. There s forest area of 26.55sqkm, 0.52 sq km garden area, and 0.52 sq km lake area and 34.2 km creek length within NMMC limits.

CHAPTER 4

4.1SAMPLE COLLECTION

Sample Collection: Vegetable Samples were collected from sector 26 Vashi Navi Mumbai in the year 2013, this farmland were chosen for this study mainly because the vegetables harvested from the selected farmland are supplied to the residents in these areas and also marketed to the nearby markets for public consumption. Vegetable samples including Kardai, Red Mat, Spinach, and Mayalu were collected from plots and samples were harvested in a 1m x1m quadrant. Vegetables were handpicked using vinyl gloves and carefully packed into polyethylene bags. Only the edible parts of each vegetable were used for analysis. In addition soil samples were collected from the sites form where the vegetables were taken. Vegetable samples were divided into two sub-samples; one sub-sample was thoroughly washed several times with tap water followed by distilled water to remove dust particles and the second sub-sample was left untreated. All vegetable samples were oven dried at 80°C for 24 hrs.

4.2 METHODS

X-ray Fluorescence Analysis. Analysis for metal determination was performed using XRF techniques. For sample preparation 20 g of dried vegetable material was ground for 20 minutes to ensure the uniform distribution of metals in a planetary mono mill (Fritsch Pulverisette 6). Two grams of ground material were taken for analysis. Measurement was performed with a Spectro XEPOS XRF spectrometer (AMETEK) using the Turbo Quant-Powders method. Samples were analyzed for Cr, Mn, Fe, Ni, Co, Zn, and Pb.

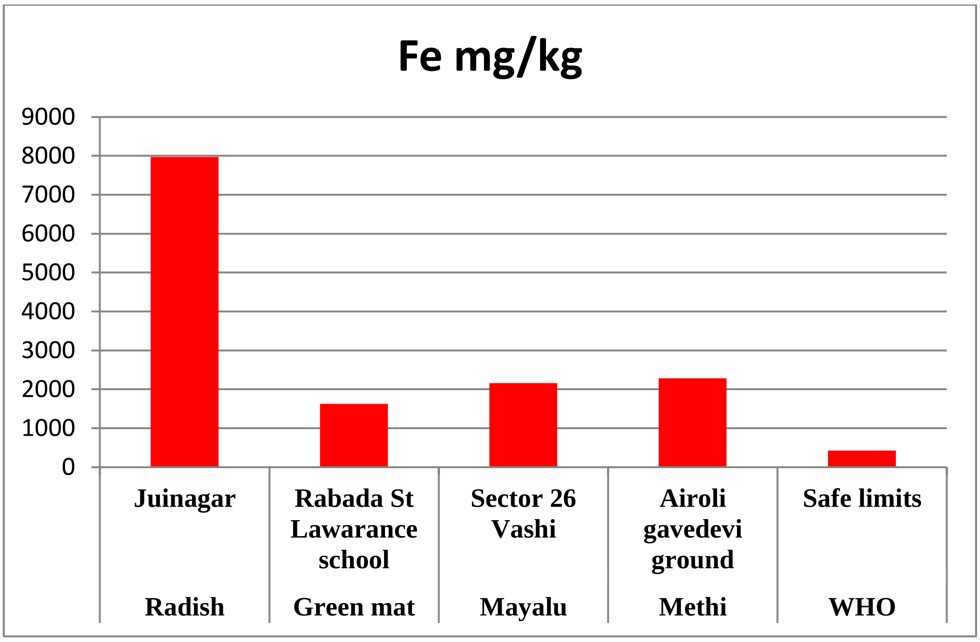
4.3 Heavy metal accumulation in different Unwashed Urban vegetables selected from different sites. Navi Mumbai Maharashtra.

Veg type	Vegetable sites	Fe	Cu	Zn	Pb	Cr	Co	Ni
Radish	Juinagar	7972	36.85	135.8	6.1	27.6	3.85	21.85
Green mat	Rabada St Lawarance school	1627.5	15.15	102.9	3.1	10.6	3.8	8.4
Mayalu	Sector 26 Vashi	2159.5	16.75	70.55	4.7	7.65	5	12.85
Methi	Airoli gavedevi ground	2278.5	21.7	114.9	5.15	7.25	4.35	11
-------	Safe limits*	425	73	100	0.3	0.05	50	67

*Source: FAO/WHO-codex alimentarius commission, 2001

Result and Discussion:-

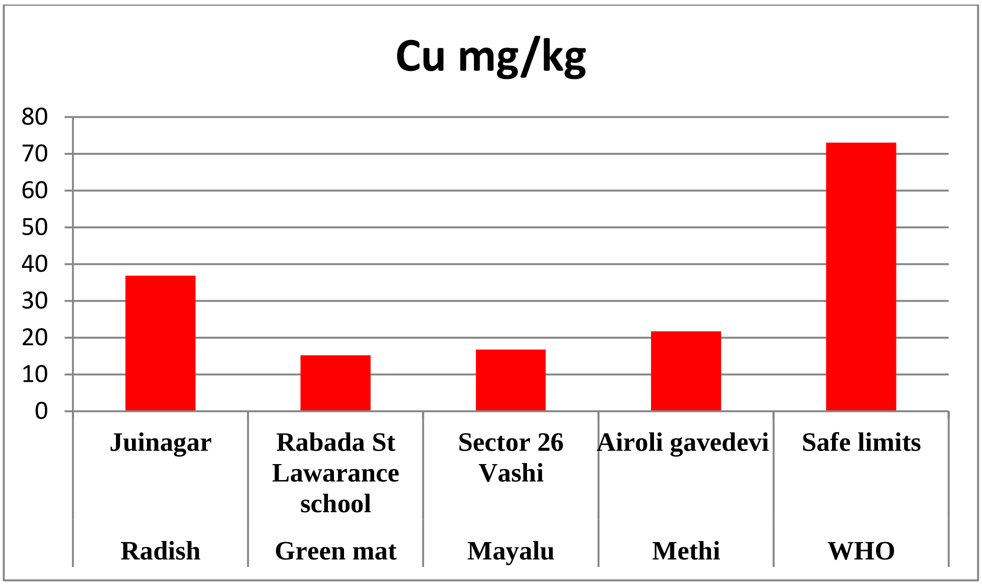
Fig-1 Iron distribution in the vegetables



The result in figure 1 shows the concentration of Fe in different vegetables i.e. Radish, Green mat, Mayalu and Methi at the different vegetable farms of Navi Mumbai, namely Juinagar, Rabada, St. Lawarance, Sector Vashi 26 and Airoli gavedevi. In figure- 1concentration of Fe in different vegetables ranges from 1627.5 mg/kg to 7972 mg/kg.

Details of the Fe concentration are as follows. Radish 7972 mg/kg>Methi Airoli gavedevi 2278.5mg/kg>Mayalu Sector 26. 2159.5mg/kg>Green Mat Rabada St. Lawarance School 1627mg/kg. The observed values of Fe in different Vegetables selected from different sites are significantly not similar, in all vegetables the observed values are above the safe limit compare with WHO Codex 2001, (425mg/kg)

Fig-2 Copper distribution in the vegetables



The result in figure 2 shows the concentration of Copper in different vegetables i.e. Radish, Green mat, Mayalu and Methi at the different vegetable farms of Navi Mumbai, namely Juinagar, Rabada, St. Lawarance, Sector Vashi 26 and Airoli gavedevi. In figure 2 concentration of Cu in different vegetables ranges from 15.15 mg/kg to 36.85 mg/kg.

Details of the Cu concentration are as follows. Radish 36.85 mg/kg>Methi Airoli gavedevi 21.7mg/kg>Mayalu Sector 26. 16.75. mg/kg>Green Mat Rabada St. Lawarance School 15.15 mg/kg. respectively.The observed values of Cu in different Vegetables selected from different sites are significantly not similar, in all vegetables the observed values are below the safe limit compare with WHO Codex 2001, (73mg/kg)

Fig-3 Zinc distribution in the vegetables

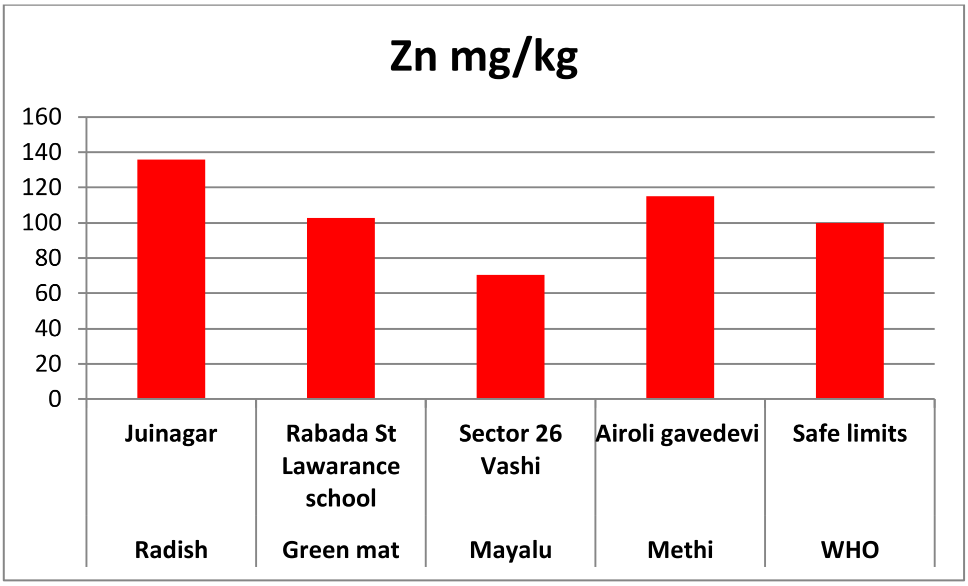


Figure 3 shows Zn concentrations in vegetables at various farms. Zn concentration in all selected sites ranges from 70.55. to 135.8. mg/kg.the order of accumulation of Zn at different sites are Radish juinagar 135.8mg/kg.> Methi,Airoli gavedevi 114.9mg/kg> Green Mat Rabada 102.9 mg/kg> Mayalu, Sector-26 respectively.

Radish had the highest concentration of Zn from Juinagar sites.

The concentrations of Zn were significantly different in all the vegetables at the different farms. Except Mayalu sector 26 all the vegetables taken from different farms show the concentration of Zn above the recommended maximum limit WHO Codex 2001(100mg/kg)

Fig-4 Lead distribution in the vegetables

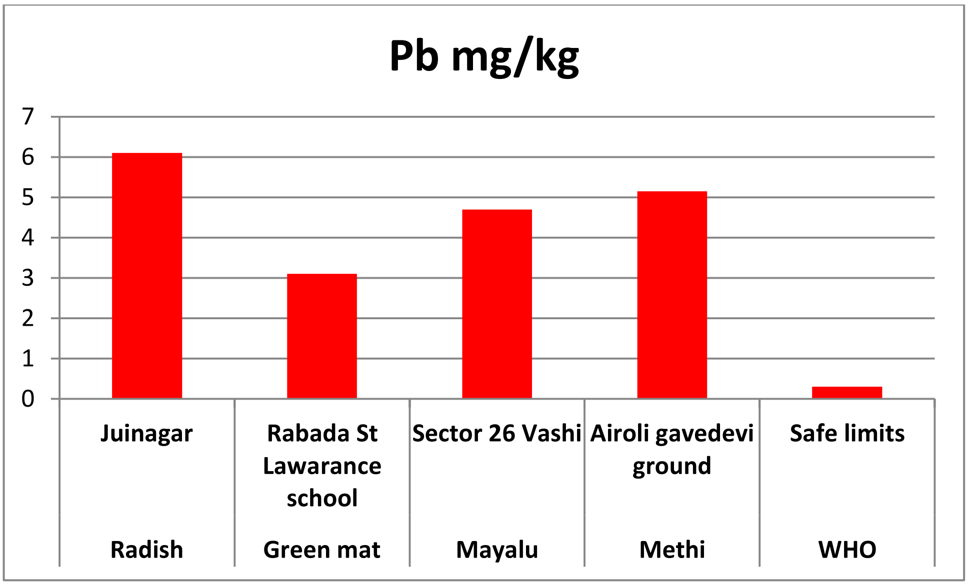
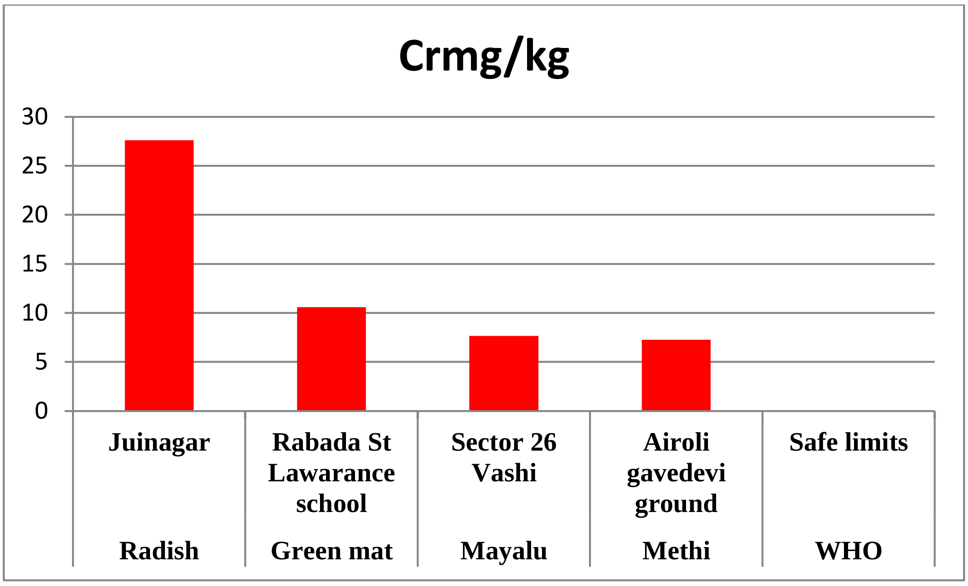


Figure 4 shows Pb concentrations in vegetables at various farms. Pb concentration in all selected sites ranges from 3.1to 6.1mg/kg.the order of accumulation of Pb at different sites are Radish juinagar (6.1mg/kg)>Methi,Airoli gavedevi(5.15mg/kg) > Mayalu, Sector-26(4.7mg/kg)>Green Mat Rabada (3.1mg/kg)respectively.

Radish had the highest concentration of Pb from Juinagar sites.

The concentrations of Pb were significantly different in all the vegetables at the different farms. All the vegetables taken from different farms show the concentration of Pb above the recommended maximum limit WHO Codex 2001(0.3mg/kg)

Fig-5 Chromium distribution in the vegetables



Radish vegetable from Juinagar site shows the highest concentration of Cr. (fig.5), in all vegetables sampled Concentration of Cr ranging from 7.25 mg/kg to 27.6 mg/kg.

The concentration of chromium at different vegetable farms was distributed as follows: Radish Juinagar27.6 mg/kg> Green mat10.6mg/kg>Mayalu7.65mg/kg> Methi 7.25mg/kg respectively the concentrations of Cr were significantly different in all the vegetables at the different farms. All the vegetables taken from different farms show the concentration of Cr above the recommended maximum limit WHO Codex 2001(0.05mg/kg)

Fig-6 Cobalt distribution in the vegetables

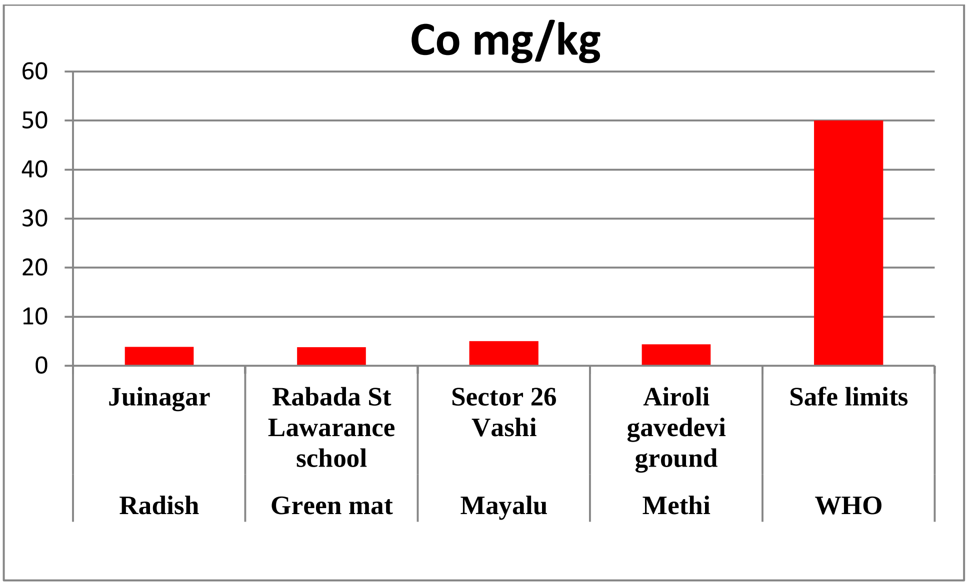


Figure 6 shows Cobalt concentrations in vegetables at various farms. Co concentration in all selected sites ranges from 5.0to 3.80 mg/kg. The concentration of cobalt at different vegetable farms was distributed as follows: Mayalu (5.0mg/kg)Methi (4.35 mg/kg)> Radish 3.85mg/kg>Green Mat3.8mg/kg respectively

The concentrations of Co were significantly different in all the vegetables at the different farms. All the vegetables taken from different farms show the concentration of Co Below the recommended maximum limit WHO Codex 2001(50.0mg/kg)

Fig-7 Nickel distribution in the vegetables

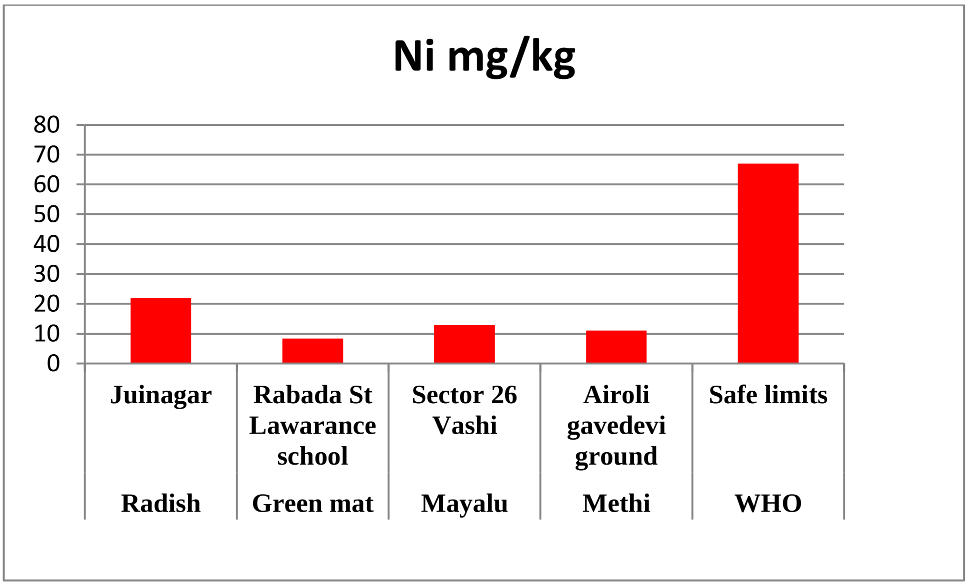


Figure7 shows Nickel concentrations in vegetables at various farms. Nickel concentration in all selected sites ranges from 8.4to 21.85 mg/kg. The concentration of Nickel at different vegetable farms was distributed as follows:

Radish , Juinagar (21.85mg/kg)> Mayalu ,Sector 26 (12.85mg/kg)>Methi ,Airoli gavedevi(11.0 mg/kg)> Green Mat, Rabada(8.4mg/kg) respectively.

The concentrations of Ni were significantly different in all the vegetables at the different farms. All the vegetables taken from different farms show the concentration of Ni Below the recommended maximum limit WHO Codex 2001(67mg/kg)

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4.4 Concentrations (mg/kg) of heavy metals in vegetables from sector-26 vashi Navi Mumbai

	Vegetable Name	Cr	Fe	Ni	Cu	Zn	Pb
Washed Vegetables	Kardai	1	391	6.55	12.5	52.15	3.35
	Red Mat	4.6	574.15	7.3	12.8	62.35	3.75
	Spinach	1.5	546.95	7.9	17.95	54.7	3.35
	Mayalu	5.95	737.65	7.7	13.5	65.95	4.7
Unwashed Vegetables	Kardai	9.05	2049	10	20.05	75.85	6.85
	Red Mat	18.35	1905.5	8	15.85	64.05	5.55
	Spinach	9.55	1893	8.9	20.9	66	4.45
	Mayalu	23.85	2094	10.4	16.25	69.25	4.85
WHO-ML*	----------	0.05	425	67	73	100	0.3

*Values refer to maximum limit of World Health Organization (CODEX,

The distribution of Chromium (Cr) Manganese (Mn) iron (Fe) Nickel (Ni) copper (Cu) Zinc (Zn) Lead (Pb) with their maximum limits in waste water irrigated vegetables are presented in Table 1. The concentrations of Cr, Mn, Fe, Ni, Cu, Zn, Pb, in different vegetable samples from irrigated sites of sector 26 vashi Navi Mumbai are listed in Tables 1. According to the data presented in Table 1, washing the vegetables resulted in lowering the metal contamination in the samples, which indicates the source of contamination had been the air-born particles. As it can be seen, the amount of reduction in all plants was not the same, and since the same washing method was applied to all the vegetables, it can be concluded that the differences may be a result of morphologic nature of the plants surface, plant tissues being even or uneven, and the amount of fluff and absorbents on the outer surface of the plants

Figure 1 Chromium distribution in the vegetables

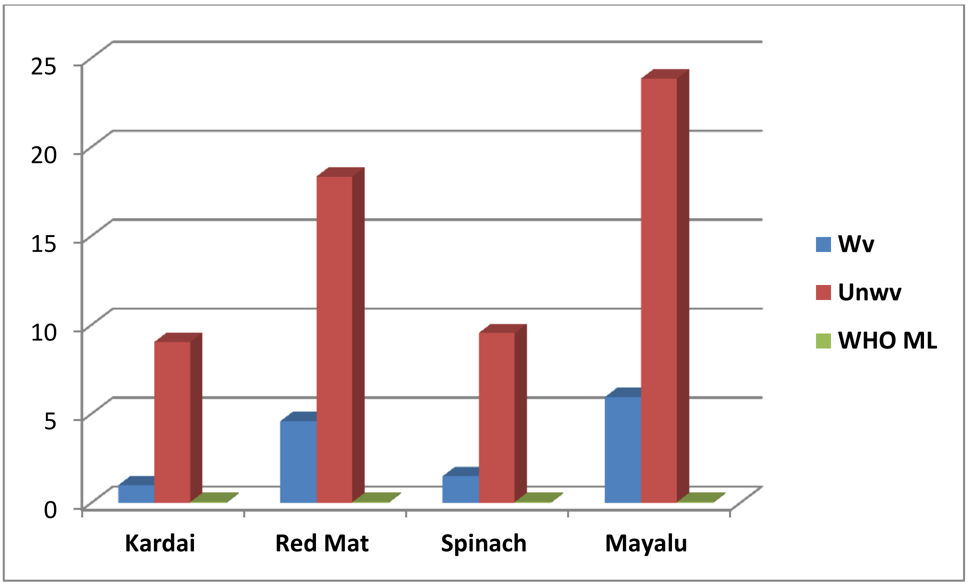


Figure 2 Iron distributions in the vegetables

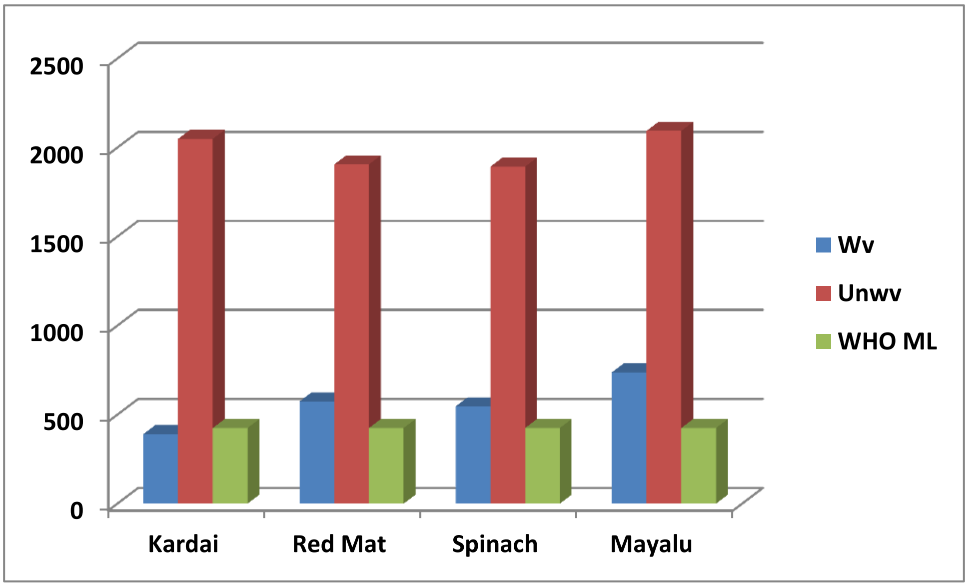


Figure 3 Nickel distributions in the vegetables

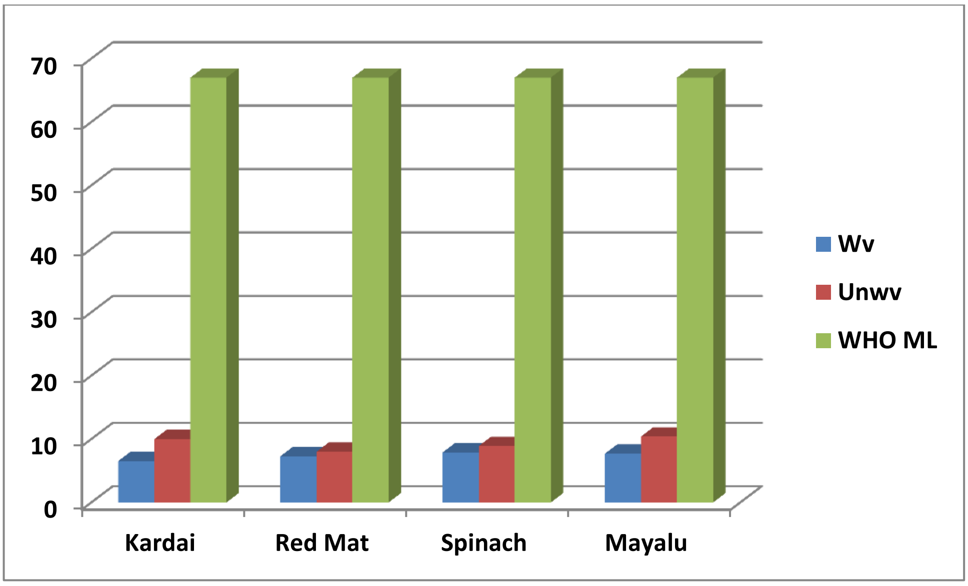


Figure 4 Copper distributions in the vegetables

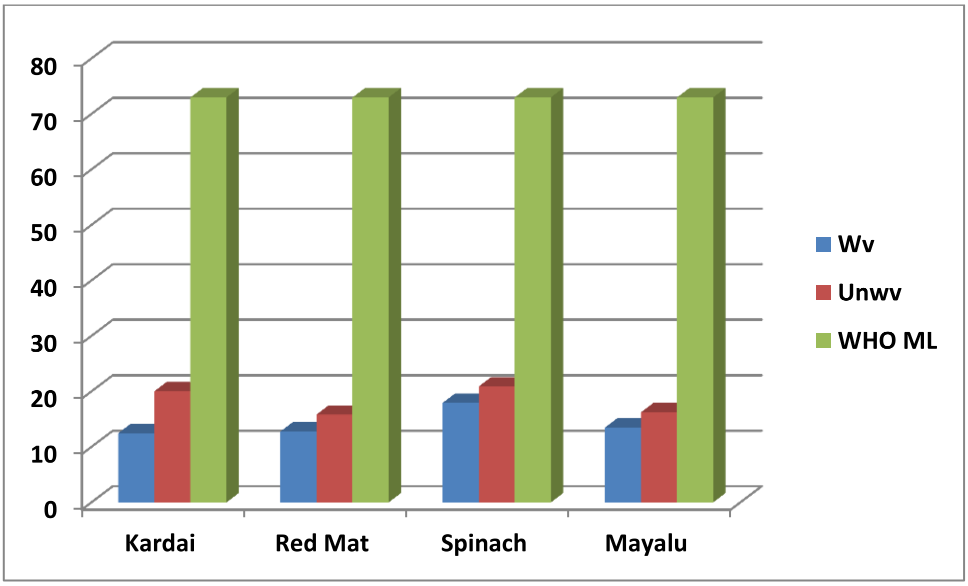


Figure 5 Zinc distributions in the vegetables

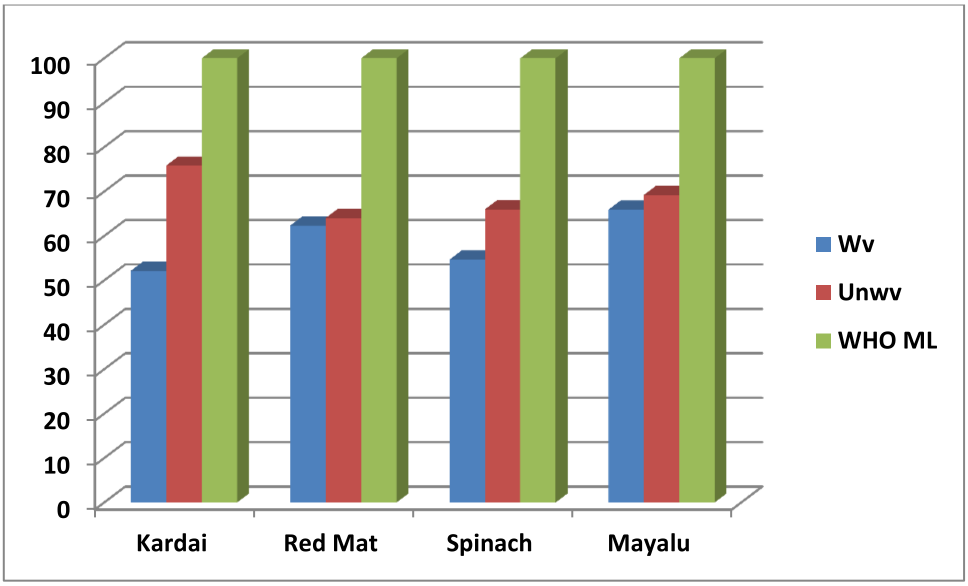
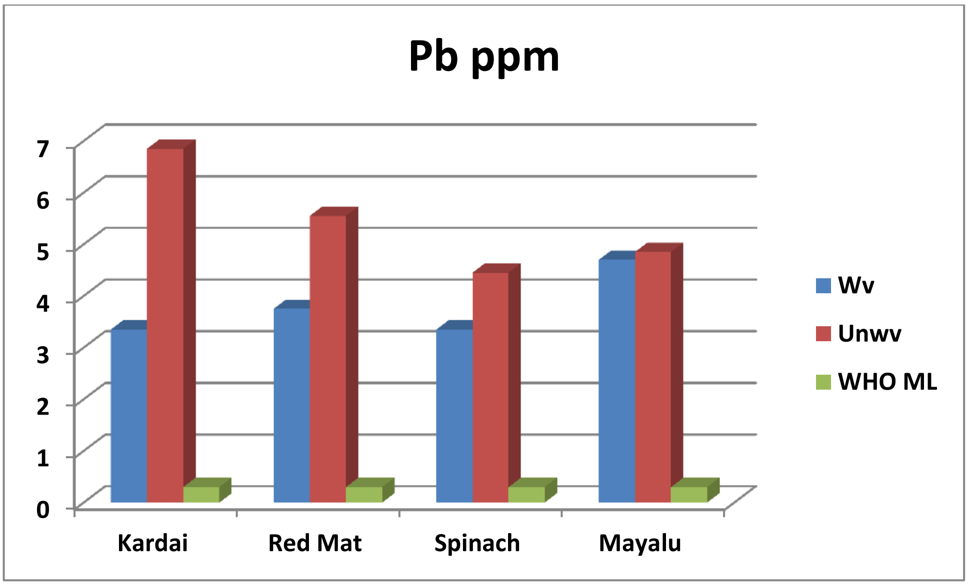


Figure 6 Lead distributions in the vegetables



DISCUSSION:-

Chromium

Human exposure to chromium occurs from both natural and anthropogenic sources. Chromium is present in the Earth's crust, with the main natural source of exposure being continental dust present in the environment, Exposure to Chromium may occur through breathing air, drinking water, or eating food containing Cr or even through skin contact. In human beings and animals, it is considered to be an essential metal for carbohydrates and lipid metabolism within a certain range of concentrations (up to 200µg/day). However exceeding normal concentrations leads to accumulation and toxicity that can result in hepatitis, gastritis, ulcers and lung cancer (17) in the present study the concentration of chromium in washed sample range (1.0to 5.95 mg/kg) and unwashed sample range(9.05 to 23.85 mg/kg) respectively. Compare WHO-ML is (0.05mk/kg)

Iron

Iron is a most essential mineral that is required for human and plants life for their growth. The iron content in the body is found in red blood cells and carries oxygen to every cell in the body. Iron also is involved in producing ATP (adenosine triphosphate, the body's energy source). Extra iron is stored in the liver, bone marrow, spleen & muscles. In the industrial fields, iron is major elemental component for all the purposes made by industries. In the present study iron was found to be higher in both washed and unwashed sample compare with WHO limits.[Fig.3] The range of iron in washed sample shows 391 to737.65 mg/kg whereas in unwashed sample 425 to 2094 mg/kg respectively.

Nickel

Nickel is one of many trace metals widely distributed in the environment, being released from both natural sources and anthropogenic activity, with input from both stationary and mobile sources. It is present in the air, water, soil and biological material. Natural sources of atmospheric nickel levels include wind-blown dust, derived from the weathering of rocks and soils, volcanic emissions, forest fires and vegetation. Nickel finds its way into the ambient air as a result of the combustion of coal, diesel oil and fuel oil, the incineration of waste and sewage, and miscellaneous sources [21]Many harmful effects of nickel are due to the interference with the metabolism of essential metals, such as Fe(II), Mn(II), Ca(II), Zn(II), Cu(II) or Mg(II), which can suppress or modify the toxic and carcinogenic effects of nickel. The toxic functions of nickel probably result primarily from its ability to replace other metal ions in enzymes and proteins or to bind to cellular compounds containing o-, s-, and N-atoms, such as enzymes and nucleic acids, which are then inhibited [22]. Nickel has been shown to be immunotoxic, altering the activity of all specific types involved in the immunological response, resulting in contact dermatitis or asthma [23]

Copper:

Copper is essential trace element to plants and the amount of copper present in plants varies with the copper content of soil on which it is grown. The copper concentration in food stuffs reported in the range of 1.75 to 9.26 µg/g. (13).In the present study the copper content in the range of 12.5 to 17.95 mg/kg in the washed sample with an average of 15.2 mg/kg. Whereas in unwashed sample the average Cu concentration reported as 15.85 to 20.9 mg/kg respectively. The concentration of Cu in plants varied much with dependent nearby factors like proximity industries and use of fertilizers and Cu based fungicides. The maximum permissible limit for Cu in vegetables is 73 mg/kg WHO and in the present study the concentration of Cu well within the limits in all the four vegetables

Zinc

Maximum permitted level for Zinc in vegetables is 100mg /kg. WHO [12] by this way, the concentration of Zn in washed vegetables was as fallows Mayalu> Red mat >Spinach >Kardai whereas in unwashed sample Kardai>Mayalu>Spinach>Red Mat [Fig.6] shows that there were not any pollution in selected vegetables compare to WHO standard level. Knowledge of Zn toxicity in humans is minimal. The most important information reported is its interference with Cu metabolism [14-15] the symptoms that an acute oral Zn dose may include: tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhea, pancreatic is and damage of hepatic parenchyma [16].

Lead:

Lead (Pb), with atomic number 82, atomic weight 207.19, and a specific gravity of 11.34, is a bluish or silvery-grey metal with a melting point of 327.5°C and a boiling point at atmospheric pressure of 1740°C. It has four naturally occurring isotopes with atomic weights 208, 206, 207 and 204 (in decreasing order of abundance). Despite the fact that lead has four electrons on its valence shell, its typical oxidation state is +2 rather than +4, since only two of the four electrons ionize easily. Apart from nitrate, chlorate, and chloride, most of the inorganic salts of lead^{2+} have poor solubility in water [10]. Lead (Pb) exists in many forms in the natural sources throughout the world and is now one of the most widely and evenly distributed trace metals. Soil and plants can be contaminated by lead from car exhaust, dust, and gases from various industrial sources.Pb^{2+} were found to be acute toxic to human beings when present in high amounts. Since Pb^{2+} is not biodegradable, once soil has become contaminated, it remains a long-term source of Pb^{2+} exposure. Metal pollution has a harmful effect on biological systems and does not undergo biodegradation [11].

In the environment, lead is known to be toxic to plants, animals, and microorganisms. Although a maximum Pb limit by WHO standards is 0.3 mg /kg

[12]. Data showed that in all vegetables, lead concentration is more than permitted level, so they are not suitable for consumption.[Fig.6]

CHAPTER.5

Conclusion:

Conclusion:- From the present study it shows that concentration of Iron (Fe), Lead (Pb), Chromium (Cr) and Zinc at Juinagar, Rabada , and Airoli Gavedevi are above the permissible limit compared with WHO whereas conc. of Cu, Co, Ni metal and Zn at sector26 shows below the permissible value

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