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Impact of Municipal Solid Waste on Heavy Metals of Soils collected near Landfill Sites of Visakhaptnam City

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ABSTRACT

The survey was conducted during the year 2021-2022 at the Regional Agricultural Research Station, Anakapalle, Andhra Pradesh to know the "effect of municipal solid waste on soil properties in Visakhapatnam city" and to asses the nutrient status of the soils near landfill sites of Visakhapatnam city as the farmers are using municipal solid waste as compost to repair the deteriorated soils. Soil samples were collected from seven dump yards at a distance of 10, 50 and 100 m from each landfill site at surface (0-30 cm) and sub surface (30-60 cm) and were analyzed for heavy metals of soils. The study clearly revealed the impact of municipal wastes on heavy metals of soil properties. The heavy metals, lead, cadmium and chromium content decreased in soil samples with increase in depth and with increase in distance from landfill sites. The distribution of nickel increase or decrease in soil did not follow any specific pattern with change in depth of soil and distance from landfill. The result of modified degree of contamination due to heavy metals indicated that the area was considerably polluted and deteriorated in terms of its quality.

Key words: *Dumpsite, Heavy metals, Landfill site, Municipal solid waste and Soil properties*

India is becoming a dumping ground for electronic waste especially used computers from United States, Singapore and South Korea which contains hazardous metals such as lead, cadmium and mercury. The environmental report revealed that about seventy per cent of the heavy metals found in landfills are from electronic wastes (Toxics Link, 2003). Further, small scale industries located in urban areas often dispose of their wastes along with municipal solid wastes.

These heavy metals pose great effects on health of human beings, living organisms and natural environmental (Amadi *et al*., 2010 and Zurbrugg, 2003) when their concentrations are above the normal threshold. For instance, if compost prepared from municipals solid waste is used as manure, some of these heavy metals are being subjected to bioaccumulation and may cause risk to human health by passing through food chain. Exposure of heavy metals may cause blood and bone disorders, kidney damage and decreased mental capacity and neurological damage (NIEHS, 2002).

The study of Arneth *et al*. (1989) and Aurangabadkar *et al*. (2001) also confirmed that landfill leachate from unlined landfills pose an important hazard for the environment, ground water and soil quality. Furthermore, Geenhuizen and Nijkamp, (1996) pinpointed that poor environmental quality of cities can deprive citizens of a good quality of life as it affects their health and consequently, adversely affect productivity and economic development. The study also highlighted the open solid waste dumping/landfill sites of municipal and other types of wastes effect on both environment and communities living around dumping sites and beyond.

Visakhapatnam is the second biggest city in Andhra Pradesh. Once a small fishing village has evolved into major Port City in South India over the decades and considered as the fastest growing city in India. The city is the biggest economic hub with both public and private sector undertakings like Visakhapatnam Steel Plant, Visakhapatnam Port, National Thermal Power Corporation, Hindustan Petroleum Corporation, Hindustan Zinc, Hindustan Shipyard, Bharat heavy Plates and Vessels and many more private companies are located in and around the city generating huge amounts of waste. As per recent estimates of Greater Visakha Municipal

Corporation, around 900 metric tonnes of solid wastes are being generated daily (GVMC, 2021) in Visakhapatnam city. In Visakhapatnam, solid waste is being disposed at different land fill sites and very small quantities of wastes are recycled as composts. Therefore, the present investigation was undertaken to evaluate the effect of municipal solid waste on soil properties.

MATERIAL AND METHODS

The present study area, Visakhapatnam, was located in Visakhapatnam district, Andhra Pradesh, bounded by the Kailasa hill in Northern side, Yarada hill in Southern side, Narava hills in Western side and Bay of Bengal in Eastern side. The study area occupies 545 km^2 lies in between 17^o 41' 12.5340" Northern latitude and 83^o 13' 6.5388" Eastern longitude. The city has witnessed rapid industrialization and has been identified as one of the fastest growing cities in the World, economically and demographically. Soil samples were collected near each landfill sites such as Cheemalapalli, Arilova, Gajuwaka, Seethammadhara, Kapuluppada, Bheemili and Anakapalle at a distance of 10, 50 and 100 m from each landfill site at surface (0-30 cm) and sub surface (30-60 cm). The sampling sites were geo-referred using Global Positioning System (GPS). The soil samples collected in cloth bags were dried under shade, pounded using a wooden pestle and mortar and passed through a 2 mm sieve. Soil samples were analyzed for heavy metals like lead, cadmium,chromium and nickel.

RESULTS AND DISCUSSION

Heavymetals

1. Lead

The data pertaining to the mean and range of lead in soil samples collected near different landfill sites in and around Visakhapatnam city are presented in table 1and depicted in the fig1. The highest value of lead in soil samples was observed at Cheemalapalli landfill site ranged from 1.56 to 2.21 mg $kg^{-1}$with a mean value of 1.81 mg kg^{-1}followed by Arilova landfill site ranged from 1.52 to1.98 mg $kg^{-1}$with a mean value of 1.74 mg kg^{-1} and Seethammadhara landfill site ranged from 1.46 to 2.02 mg kg^{-1} with a mean value of 1.73 mg kg^{-1}. The lowest value of lead in soil samples was observed at Bheemili landfill site ranged 1.37 to 1.87 mg kg^{-1} with a mean value of 1.57 mg kg^{-1}. Further, the results revealed that all the soil samples collected near the landfill sites of Visakhapatnam city were within the critical limits (85 mg kg^{-1}) with respect to the mean values of lead according to the ratings given by WHO (1996). The increase in depth of the soil sample collection and distance of soil sample colletion from the landfill showed decrease in lead content.

Concentration of lead in the soils from both areas could be as a result of its sources from automobile exhaust fumes as well as dry cell batteries, sewage effluents, runoff of wastes and atmospheric depositions owing to the close proximity of the sites to high vehicular traffic along Visakhapatnam road. Similar observations have been reported on Ponama dumpsite soils by Mpofu *et al.* (2013) where the concentration of lead was maximum at the dumpsite soils as compared to non-dumpsite soils. Izhar *et al.* (2014) also noticed high concentration of lead at the dumpsite soils as compared to non-dumpsite soils and they quoted that pH and organic matter are the main factors affecting the mobility and bio availability of lead in soil.

2. Cadmium

The data pertaining to the mean and range of cadmium in soil samples collected from different landfill sites in and around Visakhapatnam city are presented in table 1 and depicted in the fig 2. The highest value of cadmiumin soil sample was observed at Gajuwaka landfill site ranged from 0.16 to 2.65 mg $kg^{-1}$with a mean value of 1.29 mg kg^{-1} followed by Bheemili landfill site ranged from 0.68 to1.95 mg $kg^{-1}$with a mean value of 1.24 mg kg^{-1} and Arilova landfill site ranged from 0.42 to 2.40 mg kg^{-1} with a mean value of 1.15 mg kg^{-1}. The lowest values of cadmiumin soil samples was observed at Kapuluppada landfill site ranged from 0.30-1.56 mg kg^{-1} with a mean value of 0.89 mg kg^{-1}. The results showed that the mean cadmium values in soil samples collected near the landfill sites of Visakhapatnam city were above the critical limits (0.80 mg kg^{-1}) as per the ratings given by WHO (1996).

Further, the results also clearly indicated that increase in depth led to the decrease in cadmium content in soil samples and the same trend was noticed with reference to the collection site from the landfill area. The presence of cadmium could be due to the discharge of municipal solid waste (MSW) at the dumpsites, which contain nickel-cadmium batteries, discarded consumer electronic products such as televisions, calculators, stereos and plastics. Similar results were noticed by Izhar *et al*. (2014). Cadmium is a non-essential metal that is toxic even when present in very low concentrations. The toxic effect of the metal is exacerbated by the fact that it has an extremely long biological half-life and is therefore retained for long periods of time in organisms after bio-accumulation (WHO, 1992).

3. Chromium

The data pertaining to the mean and range of chromiumin in soil samples collected from different landfill sites in and around Visakhapatnam city are presented in table 1 and depicted in the fig 3. The highest value of chromium in soil sample was observed at Kapuluppada landfill site ranged from 0.89 to 2.63 mg kg^{-1} with a mean value of 1.65 mg kg^{-1} followed by Seethammadhara landfill site ranged from 0.65 to 1.96 mg kg^{-1} with a mean value of 1.35 mg kg^{-1}, Arilova landfill site ranged from 0.56 to 1.80 mg kg^{-1} with a mean value of 1.34 mg kg^{-1} and Gajuwaka landfill site ranged from 0.33 to 1.99 mg $kg^{-1}$with mean value of 1.34 mg kg^{-1}. The lowest value of chromium in soil sample was observed at Gajuwaka landfill site ranged from 0.20 to 1.96 mg kg^{-1} with a mean value of 0.95 mg kg^{-1}. The rresults also indicated the chromium values in soil samples collected near the landfill sites of Visakhapatnam city were within the critical limits (100 mg kg^{-1}) as per the ratings given by WHO (1996). Mpofu *et al*. (2013) also reported that there is a potential to buildup and accumulation of metal chemical contamination if proper disposal of industrial wastes is not immediately affected. Further, the results indicated the accumulation of more chromium in top layers of the soil and near to the dumping sites compared to the away from the dumping site and deep soil samples.

Sources of chromium in the soils could be waste consisting of chromium batteries, coloured polythene bags, discarded plastic materials and empty paint containers. The other sources of chromium might be due to wastes from household chemicals and cleaners, diesel engines utilizing anti-corrosive agents, rubber, candles and matches etc. Anthropogenic input of chromium comes from solid wastes, where approximately 30% of Cr originates from plastics, packaging materials and lead chromium batteries (Olakunle *et al.*, 2018).

4 Nickel

The data pertaining to the mean and range of nickel in soil samples collected from different landfill sites in and around Visakhapatnam city are presented in table 1 and depicted in the fig 4. The highest value of nickel in soil sample was observed at Anakapalle landfill site ranged from 1.56 to 3.12 mg kg^{-1} with a mean value of 2.53 mg kg^{-1} followed by Arilova landfill site ranged from 1.56 to 4.40 mg kg^{-1} with a mean value of 2.42 mg kg^{-1} and Bheemili landfill site ranged from 1.68 to 3.12 mg kg^{-1} with a mean value of 2.41mg kg^{-1}. The lowest value of nickel in soil sample was observed at Gajuwaka landfill site ranged from 0.25 to 3.28 mg kg^{-1} with a mean value of 1.74 mg kg^{-1}. The results also showed that all the nickel values in soil samples collected near the landfill sites of Visakhapatnam city were within the critical limits (35 mg kg^{-1}) as per the ratings given by WHO (1996).

The distribution of nickel increase or decrease in soil did not follow any specific pattern with change in depth of soil or the distance from the landfill site. Nickel content decreases with increase in distance from landfill site in soils but there is no particular trend. Ni accumulation in soil samples is due to Ni-Cd batteries. The larger part of all nickel compounds that are released in the environment are adsorbed by the sediment or soil particles and as a result become immobile. Izhar *et al.* (2014) also noticed similar results in the soil analysis of Autonagar MSW dumpsite. The distribution of nickel in soil varies widely due to the chemical properties of metal and the soil characteristics.

The study clearly indicated the wide range of lead, cadmium, chromium and nickel in the soil samples of landfill sites of Visakhpatnam city and the presence of these elements in critical limits. Further, the concentration of all these elements except nickel decreases with the depth the soil sample collection and distance from the dumpsite whereas nickel did not showed clear pattern of accumulation in the soil. Thus, there is an urgent need to take precautionary approach to minimizing these elemts using suitable measures for the benefit of the environment and human health.

Table 1. Impact of waste disposal on DTPA extractable heavy metal status of soils in and around different landfill sites of Visakhapatnam city

Name of the Site	Distance from Landfill site (m)	Profile Depth (cm)	Lead (mg kg-1)	Cadmium (mg kg-1)	Chromium (mg kg-1)	Nickel (mg kg-1)
Cheemalapalli	10	0-30	2.21	1.63	1.96	1.45
		30-60	1.71	1.25	1.56	2.2
	50	0-30	1.92	1.45	1.26	1.89
		30-60	1.56	0.5	0.46	3.55
	100	0-30	1.79	0.8	0.3	1.65
		30-60	1.64	0.4	0.2	2.15
		Range	**1.56-2.21**	**0.40-1.63**	**0.20-1.96**	**1.45-3.55**
		Mean	**1.81**	**1.005**	**0.95**	**2.14**
Arilova	10	0-30	1.98	2.4	1.8	2.25
		30-60	1.64	1.5	1.75	1.89
	50	0-30	1.79	1.56	1.65	4.4
		30-60	1.52	0.58	1.34	1.56
	100	0-30	1.92	0.45	0.95	2.56
		30-60	1.59	0.42	0.56	1.87
		Range	**1.52-1.98**	**0.42-2.40**	**0.56-1.80**	**1.56-4.40**
		Mean	**1.74**	**1.15**	**1.34**	**2.42**
Gajuwaka	10	0-30	1.68	2.65	1.99	1.56
		30-60	1.26	1.56	1.96	3.28
	50	0-30	1.49	1.89	1.69	2.56
		30-60	1.79	1.26	1.36	1.28
	100	0-30	1.85	0.25	0.75	1.56
		30-60	1.38	0.16	0.33	0.25
		Range	**1.26-1.85**	**0.16-2.65**	**0.33-1.99**	**0.25-3.28**
		Mean	**1.58**	**1.29**	**1.34**	**1.74**
Seethammadhara	10	0-30	2.02	1.6	1.96	1.68
		30-60	1.56	1.5	1.85	2.87
	50	0-30	1.88	1.4	1.42	2.12
		30-60	1.46	0.7	1.38	3.25
	100	0-30	1.92	0.6	0.86	0.26
		30-60	1.54	0.2	0.65	2.25
		Range	**1.46-2.02**	**0.20-1.60**	**0.65-1.96**	**0.26-3.25**
		Mean	**1.73**	**1**	**1.35**	**2.07**
Kapuluppada	10	0-30	1.85	1.56	2.63	2.46
		30-60	1.56	1.25	1.95	3.25
	50	0-30	1.68	0.9	1.56	2.25
		30-60	1.73	0.55	1.45	2.12
	100	0-30	1.59	0.83	1.43	1.56
		30-60	1.46	0.3	0.89	2.24
		Range	**1.46-1.85**	**0.30-1.56**	**0.89-2.63**	**1.56-3.25**
		Mean	**1.65**	**0.89**	**1.65**	**2.31**

Bheemili	10	0-30	1.87	1.95	1.92	2.78
		30-60	1.49	1.45	1.85	1.68
	50	0-30	1.68	1.25	1.36	2.78
		30-60	1.52	1.26	1.65	3.12
	100	0-30	1.49	0.9	0.65	1.89
		30-60	1.37	0.68	0.58	2.56
		Range	**1.37-1.87**	**0.68-1.95**	**0.58-1.92**	**1.68-3.12**
		Mean	**1.57**	**1.24**	**1.33**	**2.41**
Anakapalle	10	0-30	1.89	2.5	1.46	2.46
		30-60	1.56	1.5	1.25	3.12
	50	0-30	1.82	1.35	1.65	2.78
		30-60	1.45	1.16	0.96	1.56
	100	0-30	1.38	0.25	0.75	2.15
		30-60	1.48	0.1	0.45	3.12
		Range	**1.38-1.89**	**0.10-2.50**	**0.45-1.46**	**1.56-3.12**
		Mean	**1.6**	**1.14**	**1.08**	**2.53**

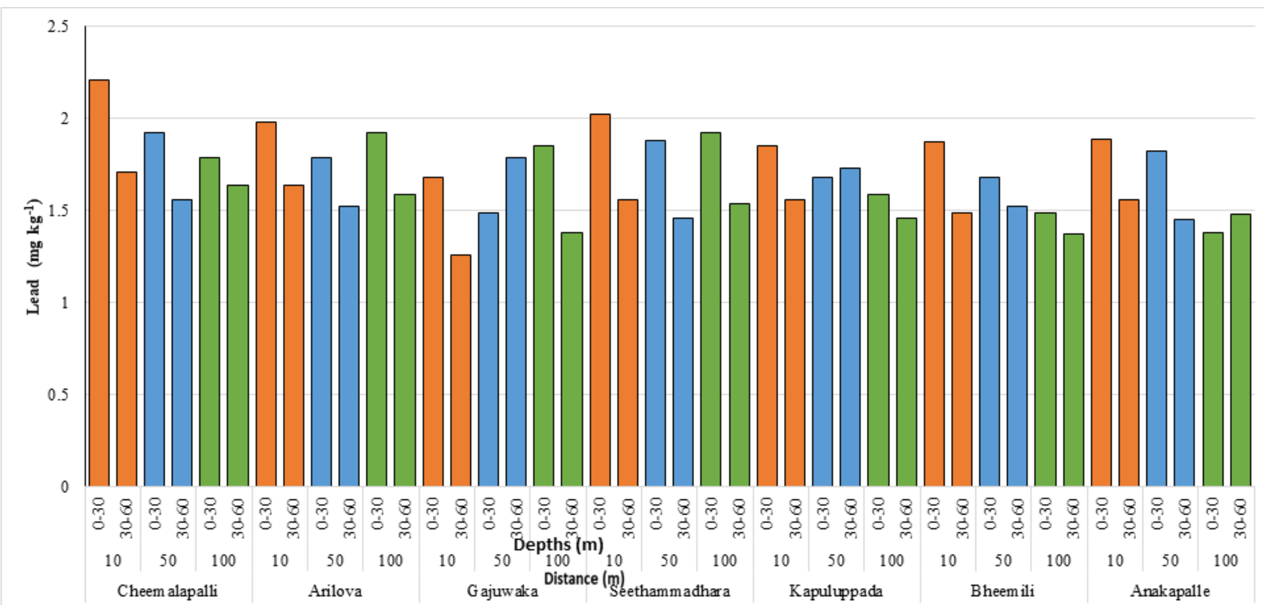

Fig 1. Lead content (mg kg^{-1}) in soil samples collected near different landfill sites

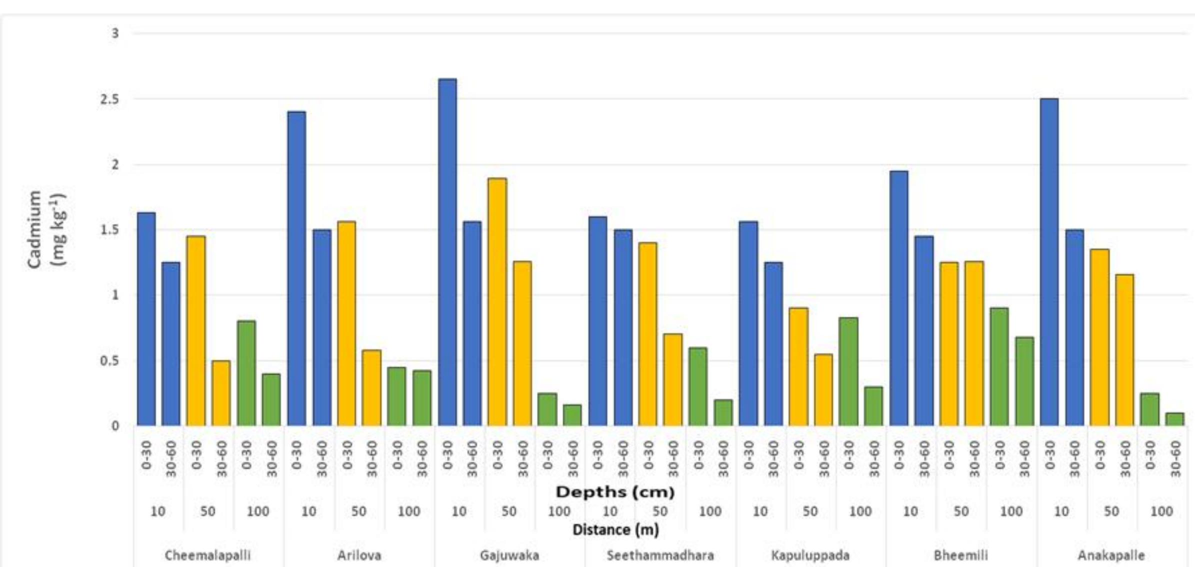

Fig 2. Cadmium content (mg kg^{-1}) in soil samples collected different landfill sites

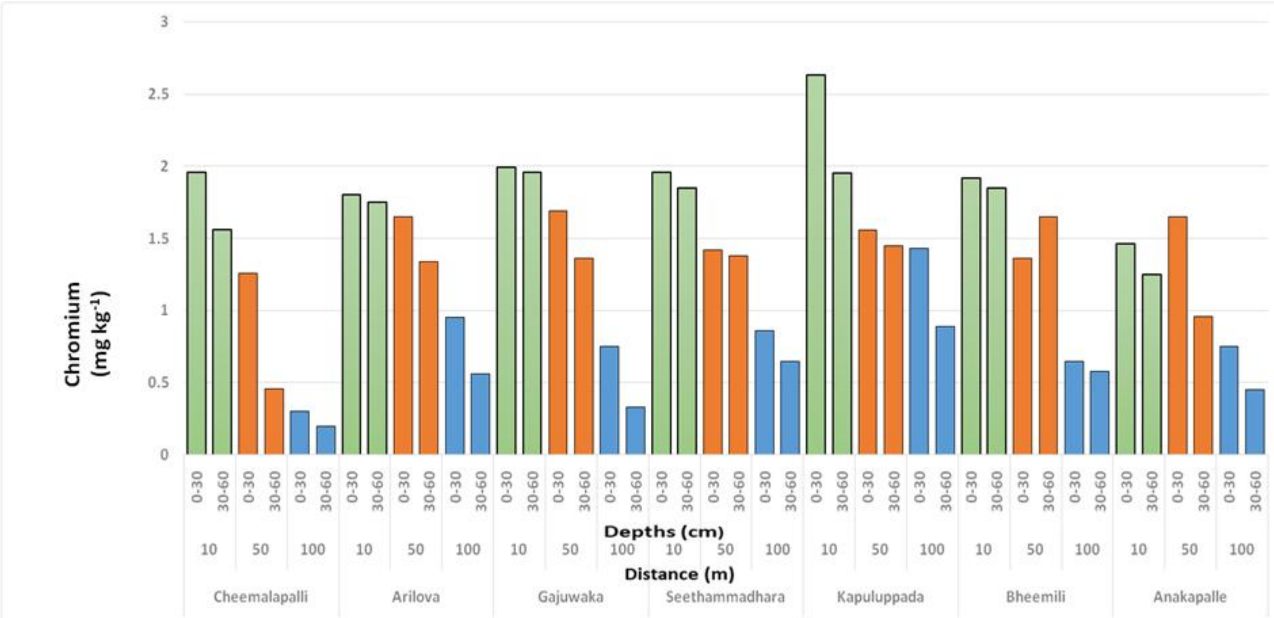

Fig 3. Chromium content (mg kg^{-1}) in soil samples collected different landfill sites

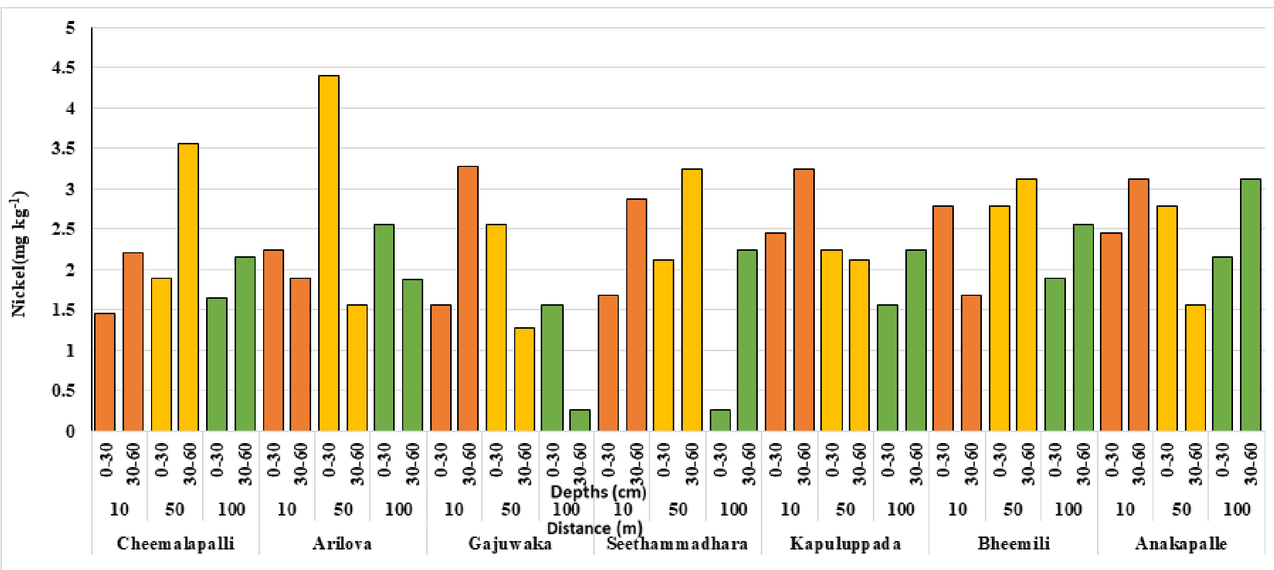

Fig4. Nickel content (mg kg^{-1}) in soil samples collected near different landfill sites

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