

## ORIGINAL ARTICLE

# Studies on Distribution Coefficient of Iodine in Soil Samples across Industrial Area

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### ABSTRACT

Trace elements may enter into ground water due to environmental processes from discharge sources. Once the element enters into the ground water it may migrate from one location to other depending on ground water flow direction. For migration study one of the most important parameter is the solid to liquid distribution coefficient,  $K_d$ . In this study, the sorption of iodine to soil column was determined. Distribution coefficient of iodine depends on chemical characteristics of soil. For determination of  $K_d$ , soil and ground water samples were collected from different locations across Tarapur industrial area, India. The chemical characterization (pH,  $\text{CaCO}_3$ , CEC (cation exchange capacity) and organic matter)) of soil was carried out to understand the dependency of chemical parameters in  $K_d$  values of iodine.  $K_d$  for iodine was determined using laboratory batch method. Equilibration time is one of the most important parameter for determination of  $K_d$ . Equilibration time for iodine was optimized and observed to be 16 hours. The distribution coefficient of iodine varies from  $65 \pm 2$  L/Kg to  $93 \pm 6$  L/Kg across Tarapur, India.

**Key Words:** Distribution coefficient, chemical parameters, correlation, ICP-AES.

Received 01.01.2017 Accepted 30.01.2017

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### INTRODUCTION

Industrial activities have increased greatly around the world during the past few decades. Trace elements are considered to be one of the main sources of environmental pollution, since they have a significant effect on ecological quality. The anthropogenic activities increasing the levels of elements owing to industrial pollution accumulate in the soil and affect the ecosystem nearby [1]. Various studies have already demonstrated that areas in close proximity to industrial activities are marked by noticeable contamination of soil and water [2-4]. Trace elements have been seen as key markers among various toxic substances released by industrial activities [5]. Presence of various trace elements in soil governs geological processes such as erosion of underground geological materials, mineralization and various chemical reactions [6]. The wastes are produced by large number of industrial activities that reach the soil through spill, direct disposal, leaks, atmospheric deposition and other pathways [7]. It is well recognized that environmental iodine deficiency can cause a number of iodine deficiency disorders (IDD), such as goiter, spontaneous abortion, sterility [8] and mental retardation [9]. Another concern with iodine in the environment is that the accumulation of radioactive isotopes of iodine, particularly  $^{131}\text{I}$  and  $^{129}\text{I}$ , can be deleterious [10]. Radioactive iodine released from nuclear facilities may contribute to the global iodine budget, and consequently lead to bio-accumulation in organisms, posing serious health risks to humans through food chain transfer.

The migration of trace elements occurs through leaching of wastes which are enriched with trace elements. The degree of migration is dependent upon amount of precipitation, permeability of soil, nature of underlying soils and proximity to both ground and surface water. Prediction of the transfer of the trace elements for the normal release, disposal and accidental or remediation scenarios in order to assess exposure requires the availability of number of important generic parameter values. Solid liquid distribution coefficient ( $K_d$ ) is one of the key parameter, which is used to predict trace element-soil interaction and trace element transport in a soil column and ground water [11]. Migration of trace elements (I) from polluted area to the natural waters is studied through measurement of retardation factor ( $R_f$ ), which is defined as the ratio of the ground water velocity to the velocity of contaminant

migration [12]. Retardation factor is determined from the measured distribution coefficient ( $K_d$ ) for the trace elements between the ground water and the soil using the relation,

$$Rf = 1 + \rho Kd/\theta$$

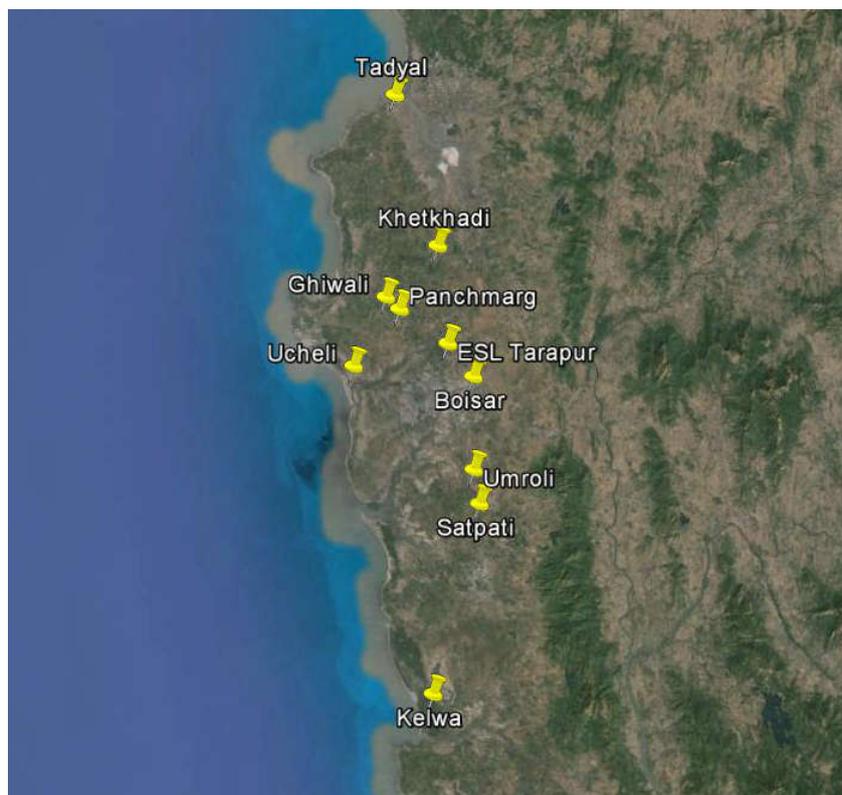
where  $\rho$  and  $\theta$  are the bulk density and porosity respectively of the soil.  $K_d$  is defined as the concentration of the contaminant per unit mass of solid phase divided by concentration per unit volume of the liquid phase at equilibrium [13]. Trace elements sorption may be dependent on soil properties such as pH,  $\text{CaCO}_3$ , organic matter content and cation exchange capacity [14].

In the present study the soil and ground water samples were collected from ten locations across Tarapur industrial area, India. After sampling the samples were initially processed and chemically characterized in the laboratory. Distribution coefficient for iodine was estimated using laboratory batch method [15]. Iodide was analyzed using inductively coupled plasma atomic emission spectrometry (ICP-AES) (Horiba Jobin Yvon). Since distribution coefficient of iodine is a function of soil and ground water parameters which affects the  $K_d$  values. To obtain accurate prediction the correlation between  $K_d$  values and soil parameters were also carried out.

## MATERIALS AND METHODS

### Study Area

Tarapur is a census town in Palghar district in the Indian state of Maharashtra. Tarapur also houses two huge industrial estates which includes bulk drug manufacturing units, speciality chemical manufacturing units, steel plants and few textile plants, which is located some 45 km north of Virar, on the western railway line of Mumbai suburban division. Tarapur generally has humid and muggy weather; the month of May is the warmest one in Tarapur wherein the temperature spins between 32 degree Celsius and 40 degree Celsius. Tarapur is coolest in the month of January as the maximum temperature recorded is around 24 degree Celsius, and the minimum so far has been 18 degree Celsius. The average annual precipitation is 2,167 mm (85 in) and the prevailing wind direction is from the west. Sampling locations across Tarapur is represented in fig. 1.



**Figure No. 1:** Sampling Locations.

### Sample Collection and Processing

Ten sampling locations were selected across Tarapur industrial area, India. All samples were collected by grab sampling process using wooden spatula. Soil samples were collected below 10 cm depth from the

surface and kept into polyethylene bags which were previously cleaned with 1 (M) solution of HCl and rinsed with double distilled water. The ground water samples were also collected from the same sampling locations and kept in polypropylene plastics containers which are previously cleaned with 1(M) HCl solution and rinsed with double distilled water. The soil samples were dried at 105<sup>o</sup> C in an oven and the dried samples then sieved below 2 mm using electromagnetic sieve shaker. Below 2 mm well mixed soil was taken for experimental work and ground water samples were filtered through 0.45 micron filter paper. The iodide concentration was analyzed by ICP-AES in the experiment. Chemicals used for experiment were Merck, Analar, suprapur [14, 16].

#### Characterization of soil

IS 2720, part 26 methodology was used for estimation of pH. For this in 100 mL beaker < 2mm size soil and double distilled water in 1:2.5 proportion were taken respectively by covering the watch glass allowed for one hour occasional stirring. Using the pH meter (DPH-500) the soil solution pH was measured. Before testing, the pH meter was calibrated using standard buffers (pH 4, 7 And 9).

IS 2720, Part 23 was used for estimation of CaCO<sub>3</sub>. For this in 100 mL beaker < 2mm size soil and 0.05 (N) HCl in 1:20 proportion were taken respectively. Beaker was covered with the watch glass and soil solution was vigorously stirred for one hour. After stirring the solution mixture was kept for settling. After settling 10 mL of supernatant liquid was taken in a conical flask and 2-3 drops of phenolphthalein indicator was added to it and titrated against 0.05 (N) NaOH solution.

The values of CEC were obtained by calculation from exchangeable cations. 1 g of soil was taken in a 100 mL beaker, 18 mL CH<sub>3</sub>COONH<sub>4</sub> (1N) was added, kept for 1 hour under stirring condition. Allowed to settle and filtered, remaining soil was washed 3 times with 1(N) CH<sub>3</sub>COONH<sub>4</sub>. Again soil was washed with absolute alcohol (10 mL). Evaporated and final volume was made up to 10 mL. Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>++</sup> and Mg<sup>++</sup> was analyzed in this sample by using atomic absorption spectrometry (AAS) (GBC Avanta). Sum of the equivalent concentration of these ions give CEC in soil.

Organic matter in the samples was estimated by weight loss on ignition method. 10 g of dry soil (105<sup>o</sup> C) sample (< 2 mm) was taken in a porcelain crucible covered with watch glass. The soil was heated in a muffle furnace at 360<sup>o</sup> C for 2 hours and after that final weight was taken [17-18]. Then loss on ignition (LOI) was calculated by using the following equation

$$LOI(\%) = \frac{(\text{weight at } 105^{\circ}\text{C} - \text{weight at } 360^{\circ}\text{C}) \times 100}{\text{weight at } 105^{\circ}\text{C}}$$

Ben-Dor and Banin, (1989) [19] shown that ignition temperatures in the range of 400-430<sup>o</sup> C resulted in no significant bias from thermal breakdown of carbonates. Jackson, (1958) [20] and Ball, (1964) [21] both recommended ignition temperatures of <400<sup>o</sup> C to minimize weight loss from carbonates, structural waters in clays and hydrated salts.

#### Calculation for estimation of distribution coefficient of iodine in soil

The distribution coefficient was calculated as per the following equation:

$$K_d = \left( \frac{C_0 - C_e}{C_e} \right) \times \frac{V}{m}$$

Where C<sub>0</sub> is the concentration of the initial solution (mg/L), C<sub>e</sub> is the concentration of the solution in equilibrium (mg/L), V is the volume of the solution (L), m is the amount of the adsorbent (Kg).

## RESULTS AND DISCUSSION

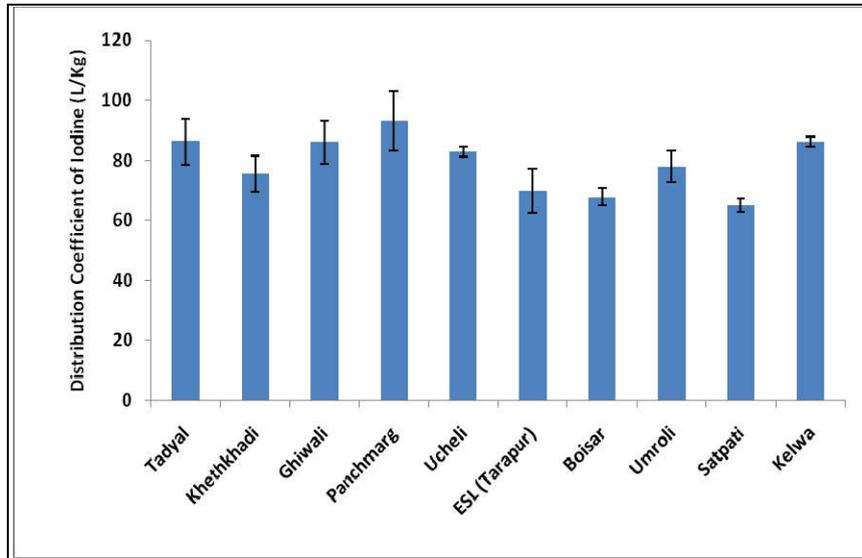
The pH, Calcium carbonate concentration, CEC, Organic Matter for soil are shown in Table 1 and compared with other literature values [22].

**Table No. 1:** Mean and ranges for the descriptive parameters of the soil samples collected from ten different locations across Tarapur industrial area, India.

Parameters	Mean	Range	Reported value	Reference
pH	7.0	6.1 – 7.9	5.0 – 8.9	[22]
CaCO <sub>3</sub> (%)	2.38	1.15 – 4.74	0.2 – 1.49	[22]
CEC (meq/100g)	8.57	3.05 – 14.14	2.86 – 20.15	[22]
Organic Matter (%)	3.62	2.53 – 5.97	3.5– 7.47	[22]

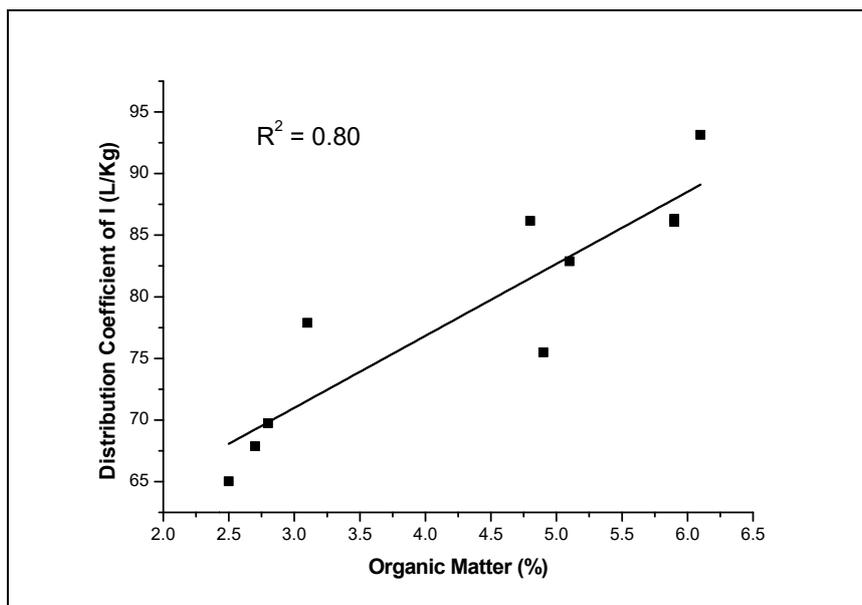
Determination of equilibration time is very much important in estimating the distribution coefficient of iodine in soil samples. For determination of equilibration time, adsorption experiment was carried out at different time interval and equilibration time was found within 16 hours for iodine.

The  $K_d$  values of iodine obtained in soil samples collected from different locations across Tarapur, India are shown in fig. 2. The  $K_d$  values of iodine varies from  $65 \pm 2$  L/Kg to  $93 \pm 6$  L/Kg across Tarapur. Highest  $K_d$  values of iodine was observed in Panchmarḡ whereas lowest  $K_d$  value of iodine was observed in Satpati. The  $K_d$  values obtained from the present study are compared with the reported values [23]. For all type of soils the  $K_d$  values of iodine obtained from present study are well within the previous studies.



**Figure No. 2:** Distribution coefficient of iodine in soil across Tarapur industrial area, India.

Previous studies show that the sorption of the anionic iodine species in soils is strongly affected by the experimental conditions, such as contact time, solid-liquid ratio, temperature [24-25] and soil properties such as organic matter and Al and Fe oxides [24, 26]. In the previous studies [23]  $K_d$  (I) increase with increasing organic matter content in the soil samples. In the present study  $K_d$  values of iodine increases linearly with increasing soil organic matter ( $R^2 = 0.80$ ) as shown in fig. 3. No significant correlation observed between soil  $K_d$  values and different soil parameters like pH, CEC and  $CaCO_3$  content in the present study.



**Figure No. 3:** Variation of distribution coefficient of iodine with organic matter in soil samples across Tarapur industrial area, India

**CONCLUSIONS**

$K_d$  values of iodine observed in the range of  $65 \pm 2$  L/Kg to  $93 \pm 6$  L/Kg with an average of 79 L/Kg in different sampling locations across Tarapur, India. Most important soil parameter is organic matter which affects  $K_d$  values of iodine. Positive correlation was observed between  $K_d$  values of iodine and soil organic matter. There was no significant effect of iodine  $K_d$  with other soil parameters like pH, CEC and  $\text{CaCO}_3$  content. Estimated site specific distribution coefficient values of iodine will be useful for prediction of contaminant transport from industrial site like Tarapur.

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**CITE THIS ARTICLE**

Sukanta Maity, Sandeep P., C. B. Dusane, D. K. Chaudhary, S. K. Sahu and G. G. Pandit. Studies on Distribution Coefficient of Iodine in Soil Samples across Industrial Area. *Res. J. Chem. Env. Sci.* Vol 5 [1] February 2017. 73-78