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RESEARCH ARTICLE

Interference Study of Phosphates and other impurities affecting the Estimation of Fe²⁺ions from River Patalganga

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Abstract

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The Patalganga River basin is delimited by several steel industries. The expected iron content in the river sample was on the higher side; however, the results acquired were in disparity with the expected values. Hence, it became necessary to carry out a study on interfering radicals in the estimation of Iron from the river samples. Taking into consideration the other industries in the industrial belt, the study was limited to certain impurities only. The masking of iron was studied by varying the conditions of the iron standards using a wide range of impurities like Phosphates and other radicals like Al, Zn, Pb, Cd, and Cu. The results revealed that when the concentrations of Iron and Phosphate are in 1:1 ratio almost 90.39% of the iron was being suppressed.

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Introduction:-

Iron is present in abundance in the earth's crust. Natural waters contain only minor amounts of iron. Whereas the iron content of some deep wells and industrially contaminated streams may be very high [6]. Iron occurs in two oxidation states. In aqueous solution it is subjected to hydrolysis. Hydroxides formed in these reactions, especially ferric forms have very low solubility. The retention of iron in water is consequently affected by pH of the water. In river waters pH is not low enough to prevent hydroxide from forming. Another important feature of chemical behavior of Iron in water is its tendency to form complex ions with inorganic as well as organic materials. Inorganic complexes most likely to be found in river water are those formed with Chlorides, Fluorides, Phosphates, Sulphates and Carbonate ions [9]. A simple determination of Iron using conventional spectrophotometric methods fails to reproduce the factual outcomes. This led to invention of a novel method for determination of Iron in river water forming Ferric-ferrocyanide (Prussian blue) complex [10]. The investigations made using novel method directed that estimation of Iron in the presence of suppressing radicals like Phosphates, Sulphates, Alkali metals, Heavy metals like Al, Zn, Pb, Cd, Cu etc. was nearly impossible. Phosphates make their way to water bodies from various sources as it is used for several objectives, like many industries and water suppliers use them to reduce scale formation, laundry compounds mostly consist of phosphates whereas fertilizers and agro industries contribute correspondingly. Elvehjem and Hart made efforts to draw attention towards interference of phosphates in the determination of iron in materials of high phosphate content [1]. All the heavy metals bequeath their impression in the aquatic ecosystem. Consequently, to achieve the aim of exploring the factors prominently indulging in the estimation of Iron, the present interference study was carried out.

Materials and methods:-

Standards of suppressing ions like Phosphates, Nitrates, Sulphates, Heavy metals like Al, Zn, Pb, Cd, & Cu of various concentrations were prepared to study the upshots of these ions on range of Fe^{2+} ions for the Patalganga river water. The concentration of all the impurities added to the standard Fe^{2+} solution of different concentration and volume were planned as per the simultaneous research which was being carried out for the Patalganga river water.

The investigation was carried by altering the circumstances of Fe^{2+} ions and all the impurities added to the solution. The iron content was estimated by using 1-10 phenanthroline method on spectrophotometer at 510 nm.

Results and discussions:-

The dominance of phosphate ions makes it difficult to estimate Fe^{2+} ions in river water. The complete investigation progressed by estimating the impact of impurities on the concentration of Fe^{2+} ions and thereby acquiring the percentage of Fe^{2+} ions being suppressed. This led to finding that, of all the impurities, Phosphate was the most active suppressant. The conditions were planned so as to study the effect of concentration and volume of impurities on the concentration of Fe^{2+} ions, the details of which are presented from table 1 to table 6. Fig. 1 is the graphical representation of the findings. The results of which show that when;

Condition 1:-

The concentration of Fe^{2+} was varied which has been displayed in the table 1 keeping the volume and concentration of PO₄ constant (7 ml, 25ppm respectively). The average masking of Fe^{2+} was 63.65%.

Condition 2:-

Varying the concentration of Fe^{2+} and keeping the concentration and volume of PO₄ (25 ppm &5 ml respectively) and other impurities constant i.e. Zn, Pb, Cd, Cu (100 ppm) (1µl), Ca (20 ppm) (1 ml), Al (10 ppm) (1ml), Mg (10ppm) (1 ml) and SO₄ (0.2 ppm) (1ml). When the Phosphate standards were supplemented with the impurities like Zn, Pb, Cd, Cu, Al, Ca, Mg and SO₄ the % masking achieved in Condition 1 decreased by approximately 10% i.e. the average masking of iron content acquired was 55.44%.

Condition 3:-

The concentration of Fe^{2+} was kept constant at 306 ppm (A). However varying the concentration of phosphates and keeping the volume of PO₄ constant (10 ml) the investigation was carried out without adding the other impurities. The results acquired displayed that as the concentration of PO₄ standard rose gradually, there was a consequent increment in the percentage of masking of Fe²⁺ ions. This increment shows that when Iron and Phosphate are in 1:1 ratio, the masking acquired was maximum.

Condition 4:-

The concentration of Fe^{2+} (306 ppm) (A) and PO₄ (300 ppm) was constant whereas volume of PO₄ was varied without adding other impurities which gave a startling result of 90.39% masking of the Fe^{2+} ions no matter what the volume of PO₄ standard was.

Condition 5:-

The concentration of Fe^{2+} ions (236 ppm) (A) and PO₄ (200 ppm) was kept constant and the volume of PO₄ as well as other impurities was varied i.e. Zn, Pb, Cd, Cu (20 ppm), Ca (20 ppm), Al (10 ppm), Mg (10 ppm), SO₄ (20 ppm). The masking of Fe²⁺ ions was found to be reduced to 80.76% when the iron and phosphate are in equivalence in concentration and on the addition of other impurities like the case was in condition 2 showing 10% decrease in the Suppression of Fe²⁺ ions achieved in Condition 4.

Condition 6:-

The concentration of Fe^{2+} (236 ppm) (A) was constant and the study progressed without the addition of PO₄ by adding the other impurities with varying volume. The results assimilated were close to expected value of approximately 10 % as in condition 2 and 5.

Many researchers [2, 3] have studied interference problems of Phosphates. Hence different methods for complexation of Phosphates [5] are applied for removal Phosphates from water. Likewise Fe hydroxide or Fe humic precipitates on the gills, eggs or other surfaces of aquatic animals, this is metal toxicity caused as an adverse effect of iron [4, 8]. The present interference study was carried out under the above stated 6 diverse conditions which very well endorse the fact that Phosphate is the only conspicuous interfering radical in the estimation of Iron in river water. During the investigation, it was observed that in the absence of phosphate the other radicals which were added played a placid role. In the same way, the investigations also revealed that the estimation of iron after waiting

for a time-period of 24-hours after addition of Phosphates to the water samples containing Fe^{2+} ions did not play any significant role as the Phosphates initiate the process of masking as soon as it comes in contact with the Fe^{2+} ions.

Similarly aeration of the samples too did not play any crucial role in the estimation of Fe^{2+} ions since the FePO₄ complex formed by the interaction of Phosphate with Iron dissociates under anoxic conditions only [11].

The study depicts that when the concentration of both Iron and Phosphate are in the ratio of 1:1 (Conditions 4 & 5) it is seen that the Fe^{2+} ions are masked immensely whatsoever the volume



Fig.1:% masking of Fe²⁺ions under various conditions of interferences

Actual Fe ²⁺	Obtained Fe ²⁺	% of Fe ²⁺ Obtained	% Masking
(ppm)	(ppm)	$(C = B/A \times 100)$	(100-C)
(A)	(B)		
~ /	()		
26.5	8.07	30.45	69.54
178.0	51.3	28.82	71.18
236.0	87.11	36.91	63.09
306.0	150.57	49.21	50.79
	Average	36.34	63.65

Table 1: % masking of Fe²⁺ ions under condition 1

Table 2: % masking of Fe²⁺ ions under condition

Actual Fe ²⁺	Obtained Fe ²⁺	% of Fe ²⁺ Obtained	
(ppm)	(ppm)	(C= B/A x 100)	% Masking
(A)	(B)		(100-C)
26.5	12.26	50.71	40.20
20.3	13.20	30.71	49.29
178.0	73.84	41.49	58.51
236.0	79.61	33.74	66.26
306.0	154.03	52.30	47.70
	Average	44.56	55.44

Table 3: % masking of Fe^{2+} ions under condition 3

Std PO ₄	Obtained Fe ²⁺	% of Fe ²⁺ Obtained	% Masking
(ppm)	(ppm) (B)	(C = B/A x 100)	(100-C)
50	121.1	40.37	59.63
150	70.9	23.64	76.36
200	68.6	22.87	77.13
300	57.69	19.24	80.76
	Average	26.53	73.47

Table 4: %	masking	of Fe ²⁺	ions	under	condition 4

	Table 4:	% masking of Fe Tons under condi	111011 4
Vol. of PO_4	Obtained Fe ²⁺	% of Fe ²⁺ Obtained	% Masking
(ml)	(ppm)	$(C = B/A \ge 100)$	(100-C)
	(B)		
15	38.0	12.67	87.33
20	23.07	7.70	92.30
25	25.96	8.66	91.34
50	28.26	9.42	90.58
	Average	9.61	90.39

Vol. of PO ₄ & Impurities` (ml)	Obtained Fe ²⁺ (ppm) (B)	% of Fe ²⁺ Obtained (C = B/A x 100)	% Masking (100-C)
05	55.96	23.72	76.27
10	44.42	18.83	81.17
15	35.76	15.16	84.84
	Average	19.24	80.76

Table 5: % Masking of Fe²⁺ ions under condition 5

Vol. of	Obtained Fe ²⁺	% of Fe ²⁺ Obtained	
Impurities	(ppm)	$(C = B/A \times 100)$	% Masking
(ml)	(B)		_
05	236.0	100.0	Nil
10	221.5	93.86	6.14
15	200.18	84.82	15.18
	Average	92.89	7.11

Table 6: % masking of Fe^{2+} ic	ons under condition 6
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Conclusion:-

The complete study discloses the factual conditions of the effects of mere presence of Phosphates in water on the estimation of Fe²⁺ ions. Investigations in the data mark a distinct report that when iron and Phosphates register themselves in a water body by virtue of their properties, they bind themselves to form Iron Phosphate complex. This interaction of Phosphates with iron is important in determining the availability of Phosphorus in many aquatic systems. Phosphates will precipitate with some metals, including ferric ions to form Ferric-Phosphate complex [10]. This FePO₄ complex possesses α -quartz structure [12], owing to which the Phosphate overshadows iron. Phosphate not only interferes in the estimation of iron but also interferes in the estimation of calcium [7]. Condition 4 & 5 indicate that when the Iron and Phosphate concentrations are in a ratio of 1:1, most of the Fe²⁺ ions are masked. Whereas the other interfering radicals like alkali metals and heavy metals along with Sulphates play a trivial role. The % masking of alkali metals and heavy metals in the Fe²⁺ ion content is approximately 10 % (condition 6) in the absence of Phosphate ions as the case was in conditions 2 & 5. When Phosphate is present along with the other interfering impurities (Sulphates, Alkali metals, Heavy metals like Al, Zn, Pb, Cd, Cu) the masking % of Fe²⁺ ions is approximately 65% (Conditions 1,2,3 & 6).

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