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STUDIES ON SORPTION PROPERTIES OF SOME BIO-POLYMERS IN THE ABSORPTION OF TOXIC METAL ION

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ABSTRACT: **Toxic metal ions such as Fe (II) and Hg (II) present in industrial waste water can be absorbed by certain biopolymers in parts per milligrams. Biopolymers like Guar Gum, Xanthan Gum, Acasia Gum, Gum Tragacanth, Sodium Alginate, Carboxymethyl Cellulose, Methyl Cellulose and Hydroxypropyl Methyl Cellulose were tested for the same. We found Hg (II) metal ion can be absorbed only by Xanthan Gum and Gum Tragacanth whereas Fe (II) metal ion absorbed by all these biopolymers from waste water. Maximum possible absorption of metal ions determined using minimal quantity of bio-polymer sample. Sorption kinetics and solution property studies of biopolymers conducted also sorption of Fe, Hg metal ions characterized at different temperature and concentrations of biopolymers. Absorption maximum for all these mixtures obtained through spectrophotometric study.**

KEYWORDS*:* **Absorption, Biopolymers, Sorption Property, Temperature effect.**

I. INTRODUCTION

Sorption is a physical and chemical process whereas Biosorption is a physico-chemical process that occurs naturally. In these days treating industrial waste water is a challenge since it contains toxic metal ions, pesticides and other organic compounds. Certain existing methods for the treatment of industrial waste water are expensive and ineffective. So we can go for biosorption method which is environment friendly filtering technique. Biopolymers are produced by living organisms also they are renewable, compostable and biodegradable [10]. In order to remove these metal ions, waste water can be treated with some biopolymers which have hydrogel properties. Hydrogels are crosslinked polymers, hydrophilic in nature, able to swell in water [1, 4, 9]. Heavy metals are naturally occurring but various activities of human have altered the balance of the same. Once it enters into the environment or to the aquatic system heavy metals cannot be degraded or destroyed easily since they are stable. They tend to accumulate in nature [3]. They move from one ecological trophic level to another by damaging the ecosystem. Due to biomagnifications or multiplication process they accumulate in living tissues, causing several health issues in humans [12]. Many metallic elements like Zinc, Iron, Copper, etc. are essential for living organisms. Although they are necessary, they become toxic at high concentrations [11]. When present above threshold concentrations, all heavy metals can be toxic. Geological weathering, solid waste dump, leaching of metals, industrial processing of metals are some sources through which metal pollution occurs. Metals used in electroplating, tanning and textile industry are highly toxic to humans [6]. Existing biosorption methods for removal of metal ions from waste water like ion-exchange, reduction, precipitation, etc. are expensive and inefficient in treating large quantities. New trends in removing heavy metals from industrial waste water are being processed [2]. The natural affinity of biological compounds for metallic elements could contribute to the purification of metal loaded waste water [8]. Thus biosorption is a beneficial option because it is both efficient and cheap [5].

II. EXPERIMENTAL

2.1 Materials and Methods

Biopolymers selected based on availability and price. Guar gum (GG), Xanthan gum (XG), Acacia gum (Ac.G), Gum tragacanth (GT), Sodium alginate (Na Alg), Carboxymethyl Cellulose (CMC), Methyl Cellulose (MC), Hydroxypropyl methyl cellulose (HPMC) were obtained from Himedia laboratories, Mumbai, India and used without additional purification. All chemicals were of Analytical reagent grade. Mohr's salt, $K_2Cr_2O_7$ and $ZnSO_4.7H_2O$ obtained from Merck India, Ammonium thiocyanate obtained from Himedia. BaDS (Barium diphenylamine Sulfonate) indicator, $HgSO_4$, Dithizone (1, 5-Diphenylthiocarbazone) and 1, 4-dioxane solution obtained from Loba chemie. Distilled water used wherever necessary. Digital pH meter (Systronics, MK-IV) used for pH study. Ultrasonic Interferometer for liquids F-81 (Mittal Enterprises) used for the estimation of ultrasonic sound velocity. Spectrophotometric analysis performed using Vis Double Beam Spectro 1203, Systronics.

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2.2 Polymer sample preparation

1000ppm Stock solution of Fe and Hg metal ions were prepared by Mohr's salt (Ferrous Ammonium Sulphate) and $HgSO_4$ respectively. Crystals of Mohr's salt and $HgSO_4$ were dissolved with dil.H_2SO_4. Bio-polymers such as Guar gum, Xanthan Gum, Acasia gum, Gum tragacanth, Sodium Alginate, CMC, Methyl cellulose and HPMC are taken with different quantities that are 20%(200mg), 15%(150mg), 10%(100mg), 5%(50mg), 1%(10mg), 0.5%(5mg), 0.1%(1mg), 0.05%(0.5mg) and 0.01%(0.1mg). Each bio-polymer mixtures taken in different beakers, to that separately added 10ml of 1000ppm Fe (II) and Hg (II) metal ion solution. Then for all the mixtures 10ml of waste water was added. These biopolymer- metal ion mixtures along with waste water mixed thoroughly with the help of magnetic stirrer. After proper mixing, the resulting mixture taken for further studies.

2.3 Sample preparation for Spectrophotometric study

For all biopolymer mixtures containing Fe (II) metal ion, ammonium thiocyanate solution and HNO_3 were added. Whereas to the mixtures containing Hg (II) metal ion, equal volumes of Dithizone and 4.5M sulphuric acid were added. To this 1, 4-dioxane solution was added later.

III. RESULTS AND DISCUSSIONS

3.1 Interaction of bio-polymer mixtures with toxic metal ions

3.1.1 Study of absorption of Fe and Hg metal ions

Initially we applied simple titration method to determine the absorption properties of bio-polymers. Solution containing10ml of 1000ppm Fe (II) metal ion was titrated against 0.003N $K_2Cr_2O_7$ solution using BaDS (Barium diphenylamine Sulfonate) indicator at lab temperature (30^0C). $K_2Cr_2O_7$ standardised with 0.003N Hypo solution. Solution containing10ml of 1000ppm Hg (II) metal ion was titrated against 0.02M $ZnSO_4.7H_2O$ solution using EBT indicator at lab temperature (30^0C). Initially $ZnSO_4.7H_2O$ standardized with 0.02M EDTA. Strength of Mohr's salt ($N_{Mohr's}$) and Strength of $HgSO_4$ (N_{HgSO4}) calculated using formula

$$N_1V_1 = N_2V_2 \qquad (1)$$

Where N_1 is the strength and V_1 is volume of Mohr's salt solution, N_2 is the strength and V_2 is volume of $K_2Cr_2O_7$ solution in case of Fe (II) analysis and N_1 is the strength and V_1 is volume of $HgSO_4$ solution, N_2 is the strength and V_2 is volume of $ZnSO_4.7H_2O$ solution in case of Hg (II) analysis. By this, amount of only Fe and Hg can be calculated as

$$N_{Mohr's}\text{*Molar weight of Fe*1000 in ppm.} \qquad (2)$$

$$N_{HgSO4}\text{*Molar weight of Hg*1000 in ppm.} \qquad (3)$$

Where $N_{Mohr's}$ is the strength of Mohr's salt solution and N_{HgSO4} is the strength of $HgSO_4$. Titration of 10ml of 1000ppm Mohr's salt solution against 0.003N $K_2Cr_2O_7$, considered as blank titration. Similarly titration of 10ml of 1000ppm $HgSO_4$ solution against 0.02M $ZnSO_4.7H_2O$ solution considered as blank titration. Solution which contains only 1000ppm of Mohr's salt, considered as blank solution of Fe and solution contains only 1000ppm of $HgSO_4$, considered as blank solution of Hg. By titration method, amount of only Fe present in 1000ppm of Mohr's salt solution (blank solution of Fe) was found to be 201ppm and amount of only Hg present in 1000ppm of $HgSO_4$ solution (blank solution of Hg) found to be 782ppm at lab temperature. Sorption properties of the metal ions are characterized by different concentrations of bio-polymer mixtures. Then different concentrations of bio-polymer mixtures along with corresponding metal ion solution were tested for absorption of Fe (II) and Hg (II) metal ions in the same way at lab temperature. It was observed that Guar gum, Xanthan gum, Acasia Gum, Gum tragacanth, Na Alginate, CMC, MC and HPMC mixtures could effectively absorb Fe (II) metal ion, only Xanthan gum and Gum tragacanth mixtures could absorb Hg (II) metal ion. Thus we can use corresponding bio-polymer mixtures for the effective removal of Fe (II) and Hg (II) metal ions from industrial waste water. Details of the observations have given in the Table 1.

Table 1. a.) Absorption of Fe (II) metal ion by different biopolymer mixtures *(ppm)* at 30^0C.

Amount of Fe (ppm)									
Concentrations	***20% (200 mg)***	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
GG	114	121	129	134	137	140	144	147	151
XG	117	130	147	150	154	157	159	163	167
Ac.G	114	120	127	131	134	137	139	142	144
GT	107	116	122	128	134	140	144	146	149
Na Alg.	134	137	141	145	147	150	154	157	159
CMC	95	105	115	119	124	129	131	136	139
MC	117	126	134	136	139	141	144	146	149
HPMC	119	128	139	143	149	152	156	159	162

1. b.) Absorption of Hg (II) metal ion by XG and GT mixtures *(ppm)* at 30^0C.

Amount of Hg (ppm)									
Concentrations	***20% (200 mg)***	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
XG	538	572	610	644	678	690	702	715	722
GT	702	714	726	738	750	757	762	766	770

At 30^0C since the polymer concentration is high maximum absorption of Fe (II) and Hg (II) metal ions has observed for 20% each bio-polymer. According to the intension of this study we found that, minimal amount i.e., 0.01% (0.0001gms) of biopolymer mixtures could absorb Fe metal ion as; 151ppm using Guar gum, 167ppm using Xanthan gum, 144ppm using Acacia gum, 149ppm using GT, 159 ppm using Sodium Alginate, 139 ppm using CMC, 149 ppm using MC and 162 ppm using HPMC mixture out of 201ppm (blank solution of Fe). Also 0.01% mixtures of XG and GT could absorb 722ppm of Hg metal ion and 770ppm of Hg metal ion respectively out of 782 ppm (blank solution of Hg) at lab temperature. The absorption of Fe, Hg metal ions goes on increased as bio-polymer concentrations decreased since concentration getting closer to blank concentration. i.e., 20% < 15% < 10% < 5% < 1% < 0.5% < 0.1% < 0.05% < 0.01% . Experiment has stopped at 20% (0.2gms) of each bio-polymer mixture because it is difficult to carry out the experiment since the thickness of mixture becomes too high after 0.2gms.

3.1.2 pH study

pH of blank Fe, Hg solution and different concentrations of biopolymer mixtures were noted at lab temperature (30^0C). Acidic pH range of 2-3 has observed in blank solution of both Fe and Hg metal ion as well as in every bio-polymer mixtures with corresponding metal ion. pH of blank solution of Fe was found to be 3.81 and that of Hg was 3.10 at lab temperature. pH values of various biopolymer mixtures along with corresponding metal ion at lab temperature are mentioned in Table 2.

Table 2. a.) pH values of different biopolymer mixtures contain Fe (II) metal ion.

Concentrations	*20% (200 mg)*	*15% (150 mg)*	*10% (100 mg)*	*5% (50 mg)*	*1% (10 mg)*	*0.5 % (5mg)*	*0.1 % (1mg)*	*0.05 % (0.5 mg)*	*0.01 % (0.1 mg)*
GG	3.78	3.63	3.85	3.80	3.74	3.71	3.80	3.83	3.81
XG	3.37	3.58	3.34	3.21	3.33	3.29	3.03	3.06	3.07
Ac. G	2.80	2.79	2.78	2.88	2.80	2.82	2.84	2.75	2.76
GT	2.87	2.85	2.88	2.89	2.78	2.80	2.88	2.79	2.89
Na Alg.	3.55	3.48	3.33	3.39	3.22	3.25	3.22	3.19	3.20
CMC	3.33	3.17	3.10	3.07	2.94	3.00	2.91	2.96	2.90
MC	2.90	2.91	2.86	2.89	2.86	2.95	2.85	2.93	2.85
HPMC	3.15	3.12	3.15	3.16	3.11	3.10	3.12	3.15	3.10

2. b.) pH values of XG and GT mixtures contain Hg (II) metal ion.

Concentrations	*20% (200 mg)*	*15% (150 mg)*	*10% (100 mg)*	*5% (50 mg)*	*1% (10 mg)*	*0.5 % (5mg)*	*0.1 % (1mg)*	*0.05 % (0.5 mg)*	*0.01 % (0.1 mg)*
XG	2.91	3.03	2.91	2.98	3.07	3.10	3.05	2.98	2.81
GT	3.08	3.07	3.10	2.79	2.98	2.88	2.94	3.08	2.82

3.1.3 Density and Viscosity studies of biopolymer mixture

Density and viscosity measurements were carried out for both Fe and Hg blank solution and also for different concentrations of biopolymer mixtures with corresponding metal ions at lab temperature. At 30^0C we found density of Fe blank was $0.3950*10^3$ (kg/m^3) and its viscosity was 0.2805mm^2/sec, density of Hg blank was $0.3950*10^3$ (kg/m^3) and its viscosity was 0.3189mm^2/sec. Density and viscosity values of various concentrations of biopolymer mixtures along with respective metal ions at are shown in Table 3 and 4 respectively. Both the parameters decreased as we move from higher concentration (20%) to lower concentrations (0.01%) of each biopolymer mixture. Mass of the substance goes on decreases from 20% to 0.01%. As a result value of density decreases.

Thickness of the substance decreases from higher concentrations (20%) to lower concentrations (0.01%). Therefore internal resistance of the mixture decreases. We know that, a liquid with high internal resistance to flow is described as having high viscosity [7]. A liquid with low internal resistance to flow is described as having low viscosity. Therefore decrease in viscosity has observed from higher concentrations (20%) to lower concentrations (0.01%).

Table 3. a.) Density values of different biopolymer mixtures contain Fe (II) metal ion.

Concentrations	*Density values [10^3 (kg/m^3)] at 30^0C*								
	20% (200 mg)	*15% (150 mg)*	*10% (100 mg)*	*5% (50 mg)*	*1% (10 mg)*	*0.5 % (5mg)*	*0.1 % (1mg)*	*0.05 % (0.5 mg)*	*0.01 % (0.1 mg)*
GG	0.3970	0.3969	0.3968	0.3967	0.3966	0.3965	0.3964	0.3963	0.3961
XG	0.3978	0.3970	0.3963	0.3962	0.3961	0.3960	0.3959	0.3958	0.3957
Ac. G	0.3975	0.3973	0.3969	0.3965	0.3961	0.3959	0.3957	0.3955	0.3954
GT	0.3974	0.3971	0.3969	0.3965	0.3962	0.3961	0.3960	0.3959	0.3958
Na Alg.	0.3980	0.3974	0.3969	0.3967	0.3966	0.3964	0.3962	0.3961	0.3960
CMC	0.3973	0.3971	0.3968	0.3965	0.3963	0.3962	0.3961	0.3958	0.3955
MC	0.3971	0.3966	0.3962	0.3961	0.3960	0.3959	0.3958	0.3957	0.3956
HPMC	0.3972	0.3968	0.3963	0.3961	0.3959	0.3957	0.3956	0.3955	0.3953

3. b.) Density values of XG and GT mixtures contain Hg (II) metal ion.

Concentr	*Density values [10^3 (kg/m^3)] at 30^0C*								
	20% (200	*15% (150*	*10% (100*	*5% (50*	*1% (10*	*0.5 %*	*0.1 %*	*0.05 %*	*0.01 %*

ations	mg)	mg)	mg)	mg)	mg)	(5mg)	(1mg)	(0.5 mg)	(0.1 mg)
XG	0.4041	0.4016	0.4003	0.3993	0.3989	0.3980	0.3974	0.3970	0.3965
GT	0.3980	0.3976	0.3973	0.3970	0.3968	0.3967	0.3966	0.3964	0.3962

Table 4. a.) Viscosity values of different biopolymer mixtures contain Fe (II) metal ion.

Concentrations	***Viscosity values(mm^2/sec) at 30^{0}C***								
	20% (200 mg)	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
GG	14.4142	9.9878	4.8055	2.1818	0.6942	0.5665	0.3496	0.3214	0.2906
XG	36.6945	25.4141	13.8747	8.3135	2.3279	1.1763	0.8996	0.5043	0.2902
Ac. G	0.4325	0.4151	0.4037	0.3956	0.3748	0.3604	0.3466	0.3282	0.3182
GT	0.6486	0.4848	0.3473	0.3365	0.3280	0.3161	0.3091	0.3003	0.2949
Na Alg.	0.4142	0.4008	0.3849	0.3654	0.3471	0.3353	0.3280	0.3133	0.3091
CMC	2.2555	1.8645	0.7698	0.5587	0.3890	0.3511	0.3232	0.3156	0.3087
MC	7.6177	5.6730	1.5910	0.7756	0.3512	0.3245	0.2950	0.2934	0.2901
HPMC	1.2165	0.9989	0.5625	0.449	0.3044	0.2993	0.29	0.2886	0.2816

4. b.) Viscosity values of XG and GT mixtures contain Hg (II) metal ion.

Concentrations	***Viscosity values(mm^2/sec) at 30^{0}C***								
	20% (200 mg)	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
XG	28.453	17.313	8.45	4.0654	2.347	0.7653	0.4331	0.3875	0.3283
GT	0.3907	0.364	0.3571	0.3421	0.3332	0.3308	0.3284	0.3208	0.3199

3.1.4 Study of Ultrasonic sound velocity of biopolymer mixtures

Determination of ultrasonic sound velocity carried out as a part of solution property studies of biopolymers with heavy metal ions. Study conducted for blank solution of Fe and Hg also for various concentrations of biopolymer mixture with corresponding metal ion at lab temperature using Ultrasonic Interferometer for liquids F-81 (Mittal Enterprises). Ultrasonic sound velocity of blank solution of Fe was 1609m/s and for blank Hg solution it was 1605m/s. The obtained values of ultrasonic sound velocity for various concentrations of biopolymer mixtures with respective metal ions are given in Table 5. No characteristic changes observed in the values of ultrasonic velocity for different concentrations of biopolymer mixtures.

Table 5. a.) Ultrasonic sound velocities of different biopolymer mixtures contain Fe (II) metal ion.

Concentration	***Ultrasonic velocity (m/s) at 30^{0}C***								
	20% (200 mg)	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
GG	1724	1655	1646	1612	1708	1688	1630	1661	1645
XG	1609	1588	1607	1613	1594	1595	1604	1611	1616
Ac. G	1575	1581	1565	1579	1590	1588	1566	1587	1597
GT	1621	1645	1630	1616	1636	1604	1639	1626	1620
Na Alg.	1584	1596	1599	1579	1595	1575	1569	1591	1588
CMC	1602	1598	1600	1621	1603	1597	1591	1616	1594
MC	1586	1593	1601	1603	1585	1590	1607	1587	1605
HPMC	1619	1624	1594	1612	1599	1587	1602	1579	1601

5. b.) Ultrasonic sound velocities of XG and GT mixtures contain Hg (II) metal ion.

Concentrations	***Ultrasonic velocity (m/s) at 30^{0}C***								
	20% (200 mg)	***15% (150 mg)***	***10% (100 mg)***	***5% (50 mg)***	***1% (10 mg)***	***0.5 % (5mg)***	***0.1 % (1mg)***	***0.05 % (0.5 mg)***	***0.01 % (0.1 mg)***
XG	1610	1595	1605	1607	1613	1616	1594	1610	1607
GT	1607	1604	1603	1600	1605	1608	1604	1602	1607

3.2 Sorption kinetics studies (Temperature Study)

3.2.1 Effect of temperature on absorption of toxic metal ion

Study of effect of temperature on absorption of Fe (II) and Hg (II) by biopolymers, their pH values, density, viscosity and ultrasonic sound velocity were conducted. Both blank solution of Fe, Hg and various concentrations of biopolymer mixtures containing corresponding metal ions were tested for the same. Temperature increased starting from lab temperature to slight higher temperatures. That was from 30^{0}C to 60^{0}C. Absorption of Fe (II) and Hg (II) from industrial waste water was found to decrease with increasing temperature for all the biopolymer mixtures even for blank solutions of metal ion. As we increase the temperature the rate of reaction increases. Particles can

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react only when they collide. By heating, particles move faster and collide more frequently. That will speed up the rate of reaction. Fig.1 and 2 represent the effect of temperature on absorption of Fe and Hg blank solutions respectively. Effect of temperature on absorption of Fe (II) metal ion by different concentrations of Guar gum mixtures (Fig.1.a), Xanthan gum mixtures (Fig.1.b), Acacia gum mixtures (Fig.1.c), Gum tragacanth mixtures (Fig.1.d), Sodium alginate mixtures (Fig.1.e), CMC mixtures (Fig.1.f), MC mixtures (Fig.1.g) and HPMC mixtures (Fig.1.h) have given below. Temperature effect on absorption of Hg (II) by Xanthan gum (Fig.2.a) and Gum tragacanth (Fig.2.b) also mentioned. Absorption curves of Fe, Hg blank (Fig.1 & 2) taken as reference curve. Remaining curves of all biopolymer mixtures with corresponding metal ion when compared with respective reference curve, lesser absorption values obtained. From graph it is clear that temperature has greater effect on reaction rate of biopolymer mixtures resulting in, decreasing temperature curve. After 60^0C, absorption found to be constant also there was negligible difference in absorption values. Hence temperature study has stopped at 60^0C for all the mixtures.

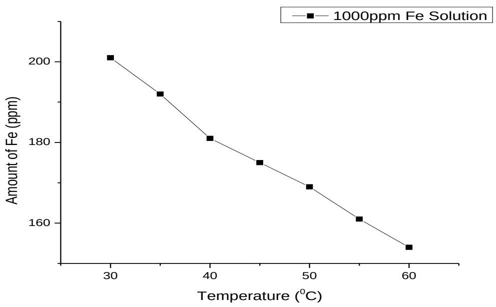

Fig.1 Effect of temperature on absorption of Fe blank

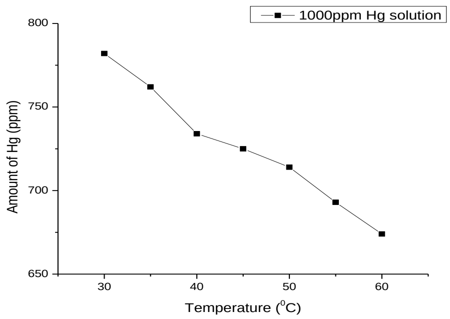

Fig.2 Effect of temperature on absorption of Hg blank

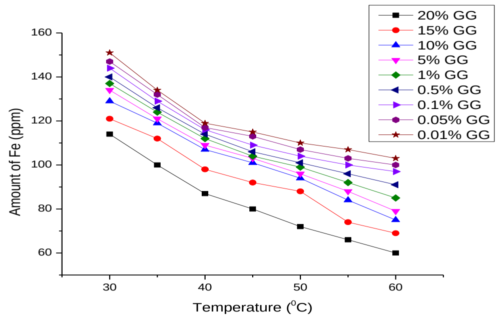

Fig.1.a Effect of temperature on absorption of Fe using GG mixtures

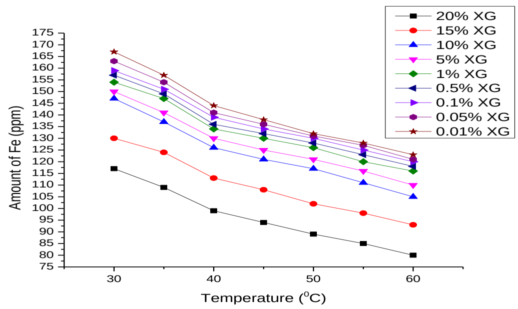

Fig.1.b Effect of temperature on absorption of Fe using XG mixtures

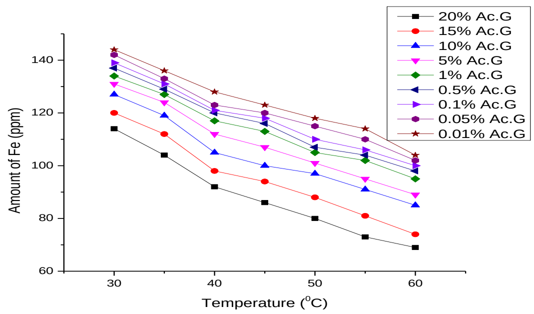

Fig.1.c Effect of temperature on absorption of Fe using Ac.G mixtures

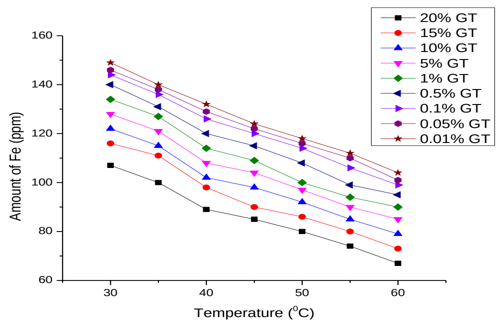

Fig.1.d Effect of temperature on absorption of Fe using GT mixtures.

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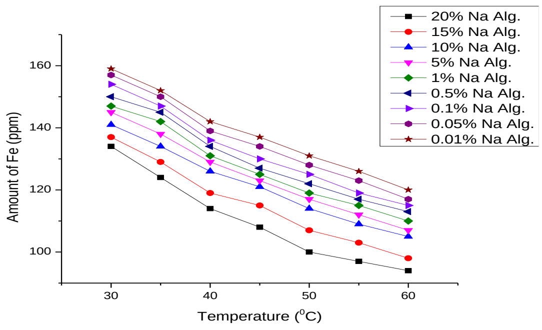

Fig.1.e Effect of temperature on absorption of Fe using Na Alg. mixtures

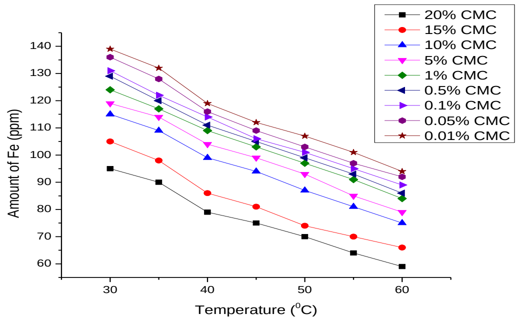

Fig.1.f Effect of temperature on absorption of Fe using CMC Mixtures

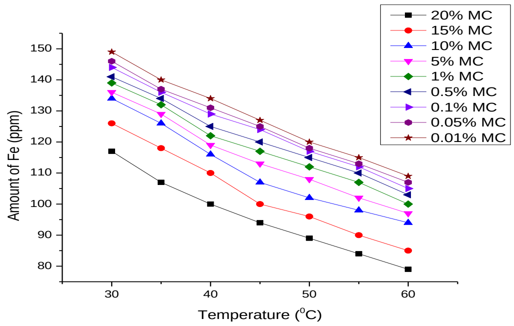

Fig.1.g Effect of temperature on absorption of Fe using MC mixtures

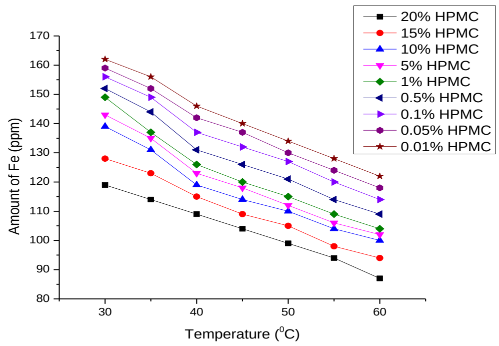

Fig.1.h Effect of temperature on absorption of Fe using HPMC mixtures

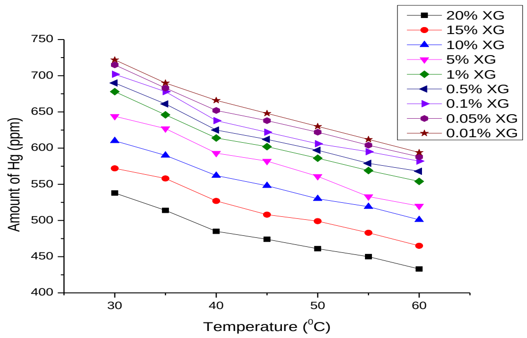

Fig.2.a Effect of temperature on absorption of Hg using XG mixtures

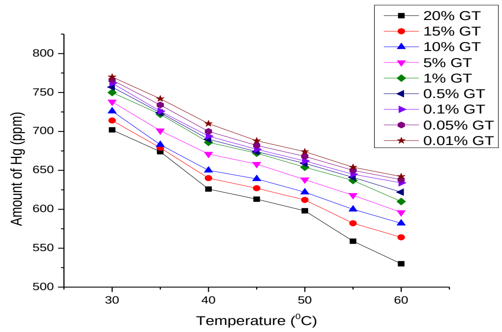

Fig.2.b Effect of temperature on absorption of Hg using GT Mixtures

3.2.2 Effect of temperature on pH values

pH of both blank solutions and their corresponding biopolymer mixtures were slightly decreased with increase in temperature. Acidic pH range (2-3pH) noticed in every mixture even though the pH values decreased. Temperature plays a significant role on pH measurements. As the temperature rises, molecular vibrations increase which results in the ability of water to ionize and form more hydrogen ions. As a result, the pH will drop. pH values of blank solutions of metal ion at different temperatures and effect of temperature on pH values of different concentrations of biopolymer mixtures are given in Table 6.

Table 6. a.) Effect of temperature on pH of Fe and Hg blank solutions

Temperature ^0C	**30**	**35**	**40**	**45**	**50**	**55**	**60**
pH of Fe blank	3.81	3.66	3.14	3.06	2.98	2.88	2.68
pH of Hg blank	3.10	3.06	2.96	2.86	2.83	2.79	2.77

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6. b.) Effect of temperature on pH of different biopolymer mixtures containing Fe metal ion

Temperature ^0C	*GG mixtures*								
	20 %	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.78	3.63	3.85	3.80	3.74	3.71	3.80	3.83	3.81
35	3.70	3.50	3.55	3.63	3.53	3.59	3.58	3.76	3.49
40	3.64	3.26	3.04	3.45	3.16	3.48	3.12	3.51	3.11
45	3.46	3.11	2.98	3.29	3.04	3.31	3.01	3.28	3.02
50	3.06	2.95	2.91	3.13	2.89	3.19	2.96	3.17	2.90
55	2.94	2.88	2.88	3.01	2.86	3.06	2.91	3.09	2.84
60	2.85	2.79	2.83	2.91	2.84	2.88	2.80	2.87	2.75

Temperature ^0C	*XG mixtures*								
	20 %	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.37	3.58	3.34	3.21	3.33	3.29	3.03	3.06	3.07
35	3.28	3.44	3.25	3.14	3.28	3.18	2.88	3.02	2.98
40	3.06	3.32	3.02	3.05	3.09	3.11	2.83	2.95	2.86
45	2.99	3.16	2.95	2.96	3.01	3.04	2.79	2.88	2.79
50	2.94	3.07	2.88	2.88	2.93	2.97	2.76	2.81	2.75
55	2.90	2.97	2.81	2.81	2.85	2.90	2.71	2.74	2.73
60	2.85	2.86	2.77	2.77	2.71	2.82	2.64	2.70	2.69

Ac.G mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	2.80	2.79	2.78	2.88	2.80	2.82	2.84	2.75	2.76
35	2.74	2.73	2.75	2.81	2.77	2.76	2.80	2.69	2.73
40	2.73	2.66	2.72	2.77	2.73	2.70	2.77	2.64	2.68
45	2.71	2.64	2.70	2.74	2.71	2.67	2.76	2.58	2.67
50	2.70	2.51	2.69	2.69	2.70	2.65	2.74	2.45	2.66
55	2.68	2.41	2.65	2.63	2.68	2.63	2.71	2.42	2.63
60	2.66	2.36	2.64	2.58	2.66	2.58	2.69	2.39	2.61

GT mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	2.87	2.85	2.88	2.89	2.78	2.80	2.88	2.79	2.89
35	2.86	2.81	2.86	2.83	2.75	2.74	2.85	2.73	2.84
40	2.84	2.74	2.82	2.72	2.70	2.70	2.81	2.66	2.81
45	2.82	2.70	2.80	2.66	2.68	2.65	2.80	2.55	2.80
50	2.80	2.66	2.78	2.63	2.66	2.61	2.77	2.48	2.78
55	2.78	2.51	2.76	2.58	2.64	2.55	2.74	2.41	2.74
60	2.76	2.46	2.74	2.50	2.61	2.50	2.72	2.32	2.72

Na Alg. Mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.55	3.48	3.33	3.39	3.22	3.25	3.22	3.19	3.20
35	3.46	3.36	3.28	3.31	3.17	3.20	3.15	3.15	3.12
40	3.42	3.18	3.22	3.25	3.12	3.15	3.11	3.11	3.05
45	3.33	3.11	3.20	3.17	3.07	3.13	3.08	3.06	3.02
50	3.29	3.05	3.18	3.11	3.05	3.06	3.06	3.04	2.98
55	3.18	2.96	3.15	3.08	3.02	3.00	3.02	2.99	2.93
60	3.08	2.88	3.10	3.03	2.99	2.95	2.98	2.94	2.86

CMC mixtures

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Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.33	3.17	3.10	3.07	2.94	3.00	2.91	2.96	2.90
35	3.30	3.11	3.04	3.03	2.88	2.93	2.90	2.91	2.86
40	3.24	3.02	3.00	2.98	2.84	2.84	2.86	2.80	2.81
45	3.20	2.88	2.98	2.92	2.80	2.77	2.83	2.73	2.79
50	3.18	2.83	2.94	2.86	2.78	2.61	2.80	2.55	2.77
55	3.11	2.69	2.90	2.81	2.75	2.50	2.76	2.49	2.72
60	3.08	2.64	2.89	2.77	2.72	2.46	2.74	2.40	2.69

MC mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	2.90	2.91	2.86	2.89	2.86	2.95	2.85	2.93	2.85
35	2.88	2.86	2.82	2.83	2.83	2.90	2.83	2.88	2.82
40	2.84	2.84	2.75	2.75	2.76	2.81	2.77	2.77	2.76
45	2.80	2.74	2.73	2.66	2.75	2.66	2.74	2.63	2.75
50	2.76	2.66	2.72	2.51	2.74	2.63	2.73	2.60	2.73
55	2.73	2.61	2.70	2.48	2.71	2.59	2.71	2.54	2.70
60	2.71	2.53	2.68	2.35	2.69	2.55	2.69	2.49	2.68

HPMC mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.15	3.12	3.15	3.16	3.11	3.10	3.12	3.15	3.10
35	3.10	3.08	3.10	3.11	3.10	3.08	3.11	3.14	3.09
40	3.08	3.07	3.06	3.09	3.08	3.04	3.07	3.10	3.06
45	3.05	3.06	3.05	3.05	3.06	3.00	3.05	3.08	3.05
50	3.02	3.03	3.04	3.03	3.05	2.99	3.02	3.04	3.07
55	3.01	3.00	3.03	3.00	3.03	2.95	3.01	3.00	3.03
60	3.00	2.97	3.02	2.97	3.02	2.93	3.00	2.93	2.99

6. c.) Effect of temperature on pH of XG and GT mixtures containing Hg metal ion

XG mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	2.91	3.03	2.91	2.98	3.07	3.10	3.05	2.98	2.81
35	2.86	3.01	2.88	2.95	3.03	3.07	3.01	2.91	2.78
40	2.77	2.96	2.77	2.90	2.98	3.05	2.96	2.85	2.73
45	2.61	2.92	2.64	2.88	2.91	3.04	2.90	2.77	2.66
50	2.53	2.88	2.59	2.84	2.87	3.00	2.86	2.63	2.62
55	2.47	2.83	2.53	2.79	2.83	2.96	2.84	2.55	2.57
60	2.40	2.77	2.40	2.75	2.69	2.94	2.77	2.42	2.55

GT mixtures

Temperature ^0C	*20 %*	*15 %*	*10 %*	*5%*	*1%*	*0.5 %*	*0.1 %*	*0.05%*	*0.01 %*
30	3.08	3.07	3.10	2.79	2.98	2.88	2.94	3.08	2.82
35	2.96	3.03	3.02	2.74	2.84	2.85	2.88	3.03	2.78
40	2.84	2.99	2.98	2.70	2.77	2.77	2.80	3.00	2.62
45	2.79	2.91	2.86	2.65	2.74	2.76	2.78	2.97	2.56
50	2.62	2.86	2.72	2.61	2.68	2.72	2.62	2.94	2.48
55	2.60	2.81	2.62	2.55	2.66	2.69	2.50	2.86	2.45
60	2.54	2.77	2.58	2.49	2.52	2.67	2.48	2.78	2.33

3.2.3 Effect of temperature on density

Density changes with temperature because volume changes with temperature. As temperature increases, the volume usually increases because the faster moving molecules are further apart. Thus increasing the volume decreases the density. Change in density values of Fe and Hg blank solutions with increasing temperature are given below in Fig.3 & 4 respectively. The temperature effect on density values for various concentrations of biopolymer mixtures containing Fe metal ion are given in Fig.3.a, 3.b, 3.c, 3.d, 3.e, 3.f, 3.g, 3.h for GG, XG, Ac.G, GT, Na Alg., CMC, MC, HPMC mixtures respectively. Similarly effect of temperature on density values of XG-Hg, GT-Hg mixtures are given in Fig.4.a, 4.b respectively. The density curves of Fe and Hg blank (Fig.3, 4)) taken as reference curve. Density curves of all biopolymer mixtures containing different metal ions when compared with corresponding reference curve, higher density values were obtained.

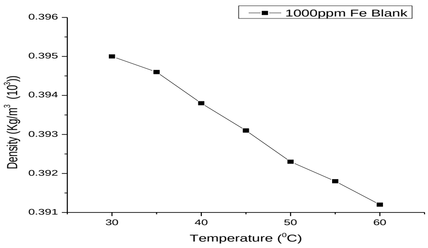

Fig.3 Effect of temperature on density of Fe blank

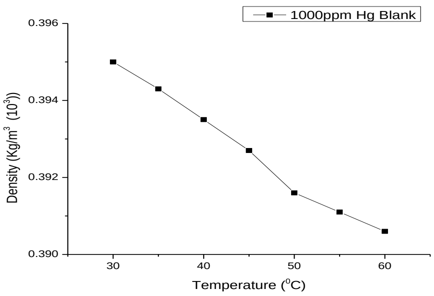

Fig.4 Effect of temperature on density of Hg blank

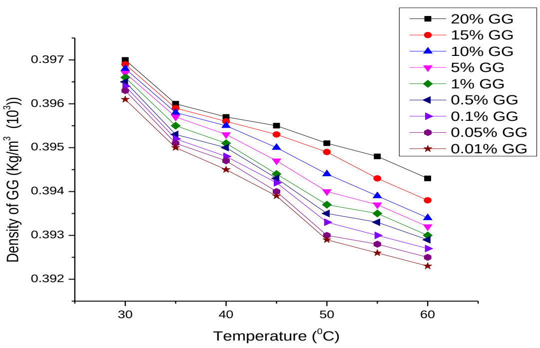

Fig.3.a Effect of temperature on density of GG-Fe mixture

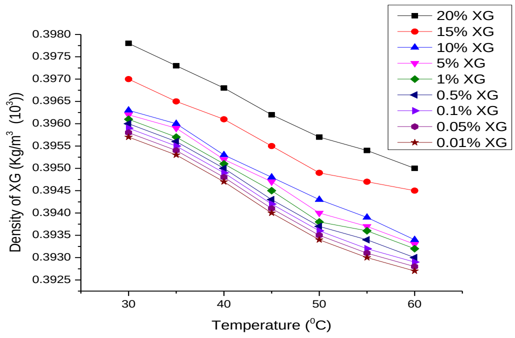

Fig.3.b Effect of temperature on density of XG-Fe mixture

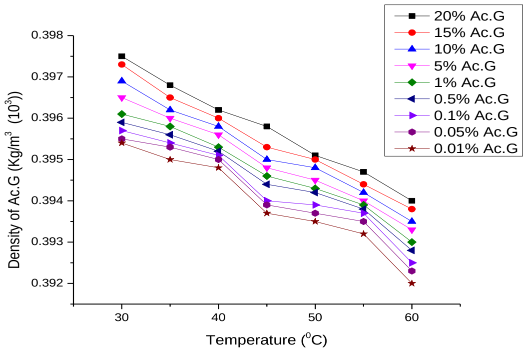

Fig.3.c Effect of temperature on density of Ac.G-Fe mixture

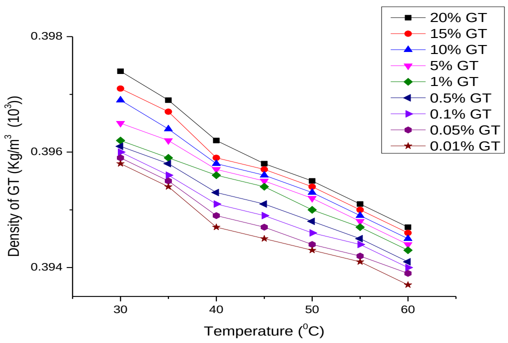

Fig.3.d Effect of temperature on density of GT-Fe mixture

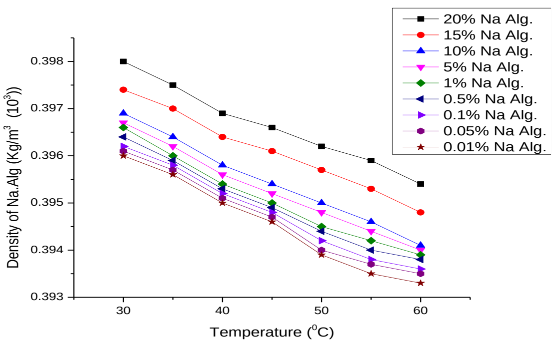

Fig.3.e Effect of temperature on density of Na Alg.-Fe mixture

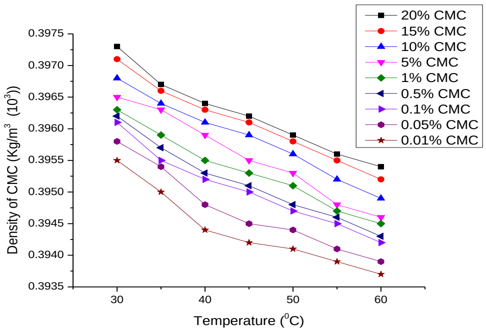

Fig.3.f Effect of temperature on density of CMC-Fe mixture

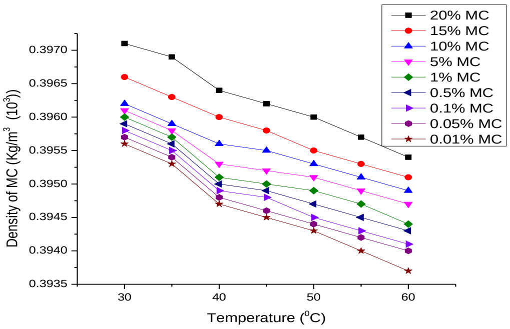

Fig.3.g Effect of temperature on density of MC-Fe mixture

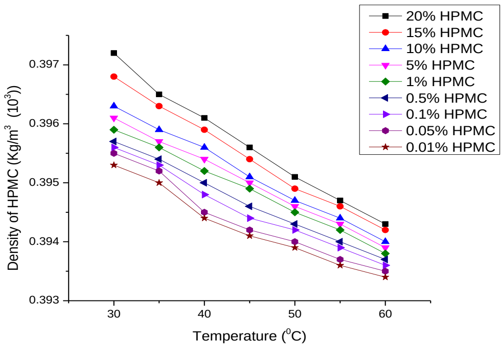

Fig.3.h Effect of temperature on density of HPMC-Fe mixtures

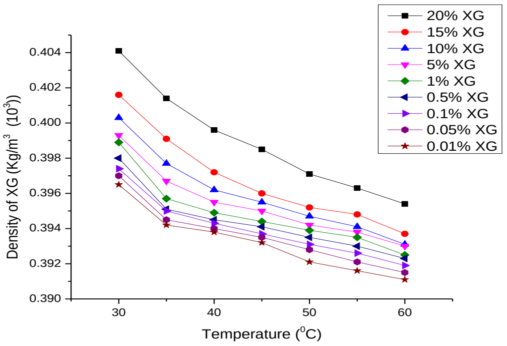

Fig.4.a Effect of temperature on density of XG-Hg mixture

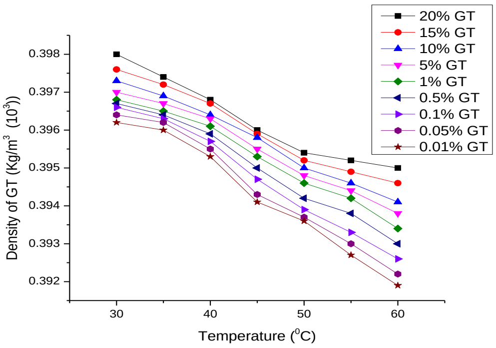

Fig.4.b Effect of temperature on density of GT-Hg mixture

As we move from higher to lower concentrations of the mixture, mass of the substance decreases density values become less. Density values of 20% and 15% mixtures of Xanthan gum-Fe (Fig.3.b), Sodium Alginate-Fe (Fig.3.e) and Methyl Cellulose-Fe (Fig.3.g) are very high. These biopolymers when mixed with Fe metal ion solution, form very thick mixture and Sodium alginate mixture becomes turbid too. Hence respective density curves lies at the top. All concentrations of Guar gum-Fe mixtures (Fig.3.a) are thick. Their initial density will be high. Later as temperature increases (after 35^0C) density slightly decreases. Acacia gum-Fe (Fig.3.c) and Gum tragacanth-Fe (Fig.3.d) mixtures dissolve quickly with Fe metal ion solution. Hence they do not form compact solution. All the mixtures of Ac.G-Fe and GT-Fe showed good difference in density values. CMC-Fe (Fig.3.f) mixtures also become little bit thick. But all these mixtures exhibit good density differences. In case of Fig.3.h, all lines are close to each other this is because of negligible difference in density values between different concentrations of Hydroxypropyl methyl cellulose mixtures.

At higher concentrations Xanthan gum usually becomes thick when it mixes with Mercury metal ion solution. Therefore such mixture 20%, 15% and 10% of XG-Hg (Fig.4.a) will give large density values. After 10% (5% XG-Fe - 0.01% XG-Fe), density values found to be closer since these mixtures will not become that much thick. All GT (20% to 0.01%) mixtures are quickly soluble with Mercury metal ion solution. Also solution will not become thick. So differences between the density values are very less.

Sorption kinetics of change in density with respect to temperature also favors the absorption of metal ions from waste water.

3.2.4 Effect of temperature on viscosity

The viscosity of liquids decreases with increase in temperature. The cohesive force between molecules of liquids decreases. At high temperature these molecules have high energy and overcome strong cohesive forces and move freely. Therefore viscosity of liquids decreases with increase in temperature. Change in viscosity values with temperature for

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Fe and Hg blank are given below in Fig.5 & 6 respectively. Fig.5.a, 5.b, 5.c, 5.d, 5.e, 5.f, 5.g and 5.h represents the temperature effect on viscosity values for different Guar gum, Xanthan gum, Acacia gum, Gum tragacanth, Sodium alginate, CMC, MC and HPMC mixtures respectively which contain Fe metal ion. Similarly Fig.6.a and 6.b represents temperature effect on viscosity of XG-Hg and GT-Hg mixtures respectively. Fig.5, 6 considered as reference curve. Viscosity curves of all biopolymer mixtures containing different metal ions when compared with corresponding reference curve, higher viscosity values were obtained.

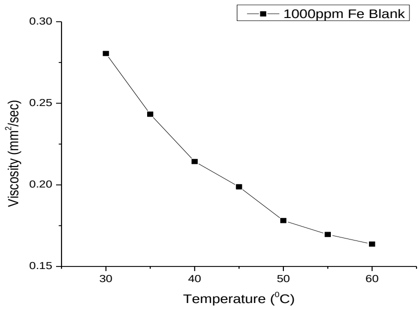

Fig.5 Effect of temperature on viscosity of Fe blank.

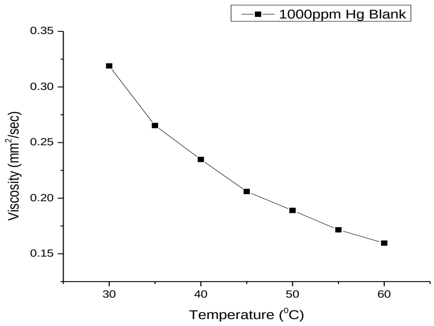

Fig.6 Temperature effect on Viscosity of Hg blank

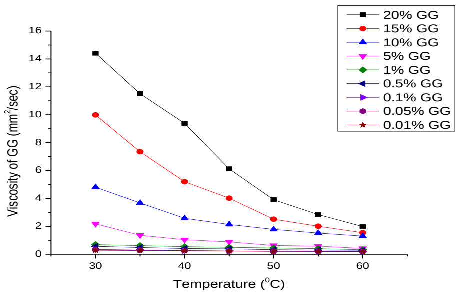

Fig.5.a Effect of temperature on viscosity of GG-Fe mixtures

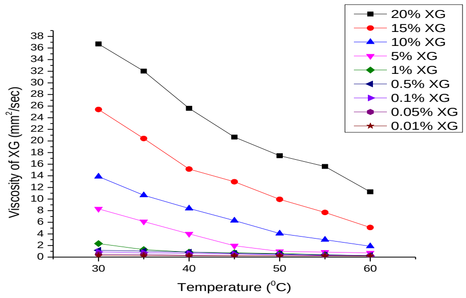

Fig.5.b Temperature effect on Viscosity of XG-Fe mixtures

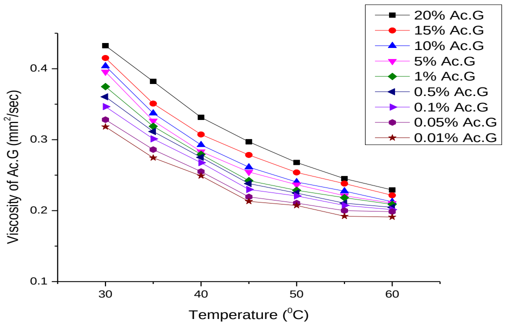

Fig.5.c Effect of temperature on viscosity of Ac.G-Fe mixtures

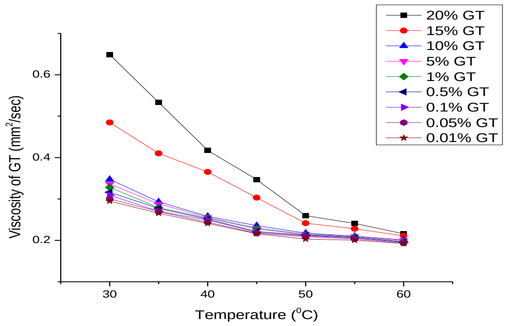

Fig.5.d Effect of temperature on viscosity of GT-Fe mixtures

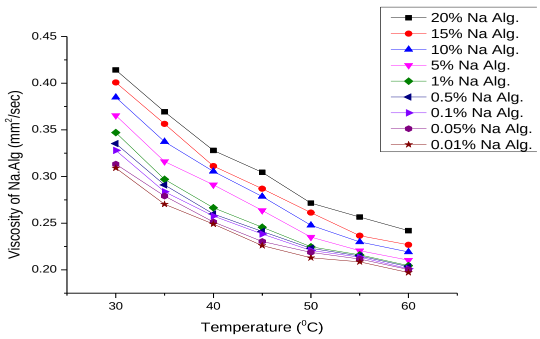

Fig.5.e Effect of temperature on viscosity of Na Alg.-Fe mixtures

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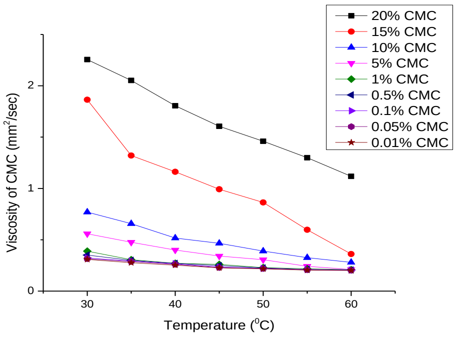

Fig.5.f Effect of temperature on viscosity of CMC-Fe mixtures

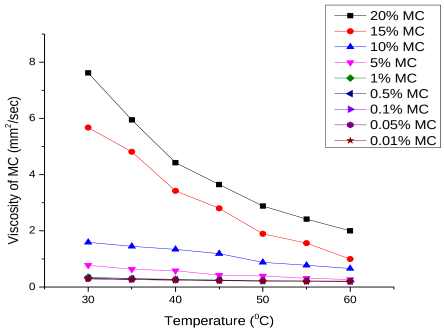

Fig.5.g Effect of temperature on viscosity of MC-Fe mixtures

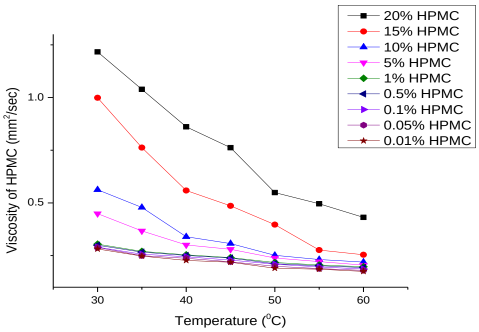

Fig.5.h Effect of temperature on viscosity of HPMC-Fe mixtures

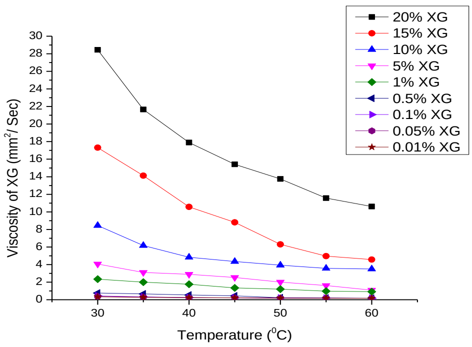

Fig.6.a Effect of temperature on viscosity of XG-Hg mixtures

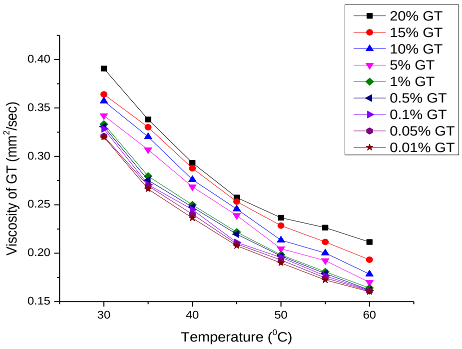

Fig.6.b Effect of temperature on viscosity of GT-Hg mixtures

Out of all biopolymer thickness of Xanthan gum-Fe (Fig.5.b) and Xanthan gum-Hg (Fig.6.a) mixtures are very high. Its viscosity values also higher than other. Thickness remains high till 10% XG whereas after 10%, becomes less thick also viscosity curves of 1%-0.01% XG mixtures of both metal ions seem to be very close or overlapping. Mixtures which become too thick when mixed with Fe metal ion solution will give higher viscosity values. Respective viscosity curves lies at the top. Such observation we can see at 20% and 15% Fe metal ion mixtures of Guar gum (Fig.5.a), Gum Tragacanth (Fig.5.d), CMC (Fig.5.f), MC (Fig.5.g) and HPMC (Fig.5.h). As concentration of mixture decreases they lose their stiffness. Hence least concentrated mixtures almost occupy the same line in the curve. Viscosity values of all Acasia Gum-Fe (Fig.5.c) and Sodium alginate-Fe (Fig.3.e) mixtures showed good difference throughout. In Fig.6.b all GT-Hg mixtures (20% to 0.01%) are quickly soluble with Hg metal ion solution also it will not become thick. Hence their viscosity curves lies very close to each other, also 1% to 0.1% mixtures seem to be overlapping.

We observed that minimal amounts of 1% to 0.01% polymer mixtures are easy to handle for effective absorbance of Fe and Hg metal ions from industrial waste water. They dissolve quickly with metal ion solution. Thickness is also less.

3.2.5 Effect of temperature on Ultrasonic sound velocity

Sorption kinetics of ultrasonic sound velocity carried out as a part of solution property studies of biopolymers with heavy metal ions. Temperature is also a condition that affects speed of sound [13]. Molecules at higher temperature have more energy thus they can vibrate faster. In this experiment, velocity of ultrasonic sound decreases as temperature rises. Ultrasonic sound velocity of blank Fe and Hg solution at different temperatures and effect of temperature on ultrasonic sound velocity of various biopolymer mixtures with corresponding metal ion are given below (Table 7). All these values decreased with increasing temperature but no characteristic changes observed between the values of ultrasonic sound velocity for different concentrations of biopolymer mixtures.

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Table 7. a.) Effect of temperature on ultrasonic sound velocity of Fe, Hg blank solutions

Temperature (^0C)	Ultrasonic Velocity of Fe blank (m/s)	Ultrasonic Velocity of Hg blank (m/s)
30	1609	1605
35	1603	1602
40	1600	1600
45	1595	1593
50	1574	1589
55	1561	1576
60	1543	1557

7. b.) Effect of temperature on ultrasonic sound velocity of biopolymer mixtures contain Fe metal ion

GG mixtures (m/s)

Temperature ^0C	20 %	15 %	10 %	5%	1%	0.5 %	0.1 %	0.05%	0.01 %
30	1724	1655	1646	1612	1708	1688	1630	1661	1645
35	1657	1623	1638	1609	1689	1659	1614	1638	1622
40	1606	1611	1619	1588	1655	1633	1601	1615	1608
45	1591	1596	1593	1570	1643	1611	1586	1593	1580
50	1586	1563	1577	1557	1618	1599	1570	1578	1566
55	1570	1541	1546	1546	1582	1574	1559	1563	1545
60	1536	1516	1531	1522	1563	1555	1541	1554	1521

XG mixtures (m/s)

Temperature ^0C	20 %	15 %	10 %	5%	1%	0.5 %	0.1 %	0.05%	0.01 %
30	1609	1588	1607	1613	1594	1595	1604	1611	1616
35	1603	1583	1601	1602	1590	1586	1598	1605	1608
40	1600	1576	1593	1593	1582	1571	1590	1597	1591
45	1597	1569	1586	1572	1560	1563	1579	1584	1583
50	1591	1550	1563	1566	1548	1548	1571	1572	1568
55	1584	1547	1555	1558	1522	1542	1556	1559	1554
60	1578	1538	1541	1544	1504	1533	1547	1543	1539

Ac.G mixtures (m/s)

Temperature ^0C	20 %	15 %	10 %	5%	1%	0.5 %	0.1 %	0.05%	0.01 %
30	1575	1581	1565	1579	1590	1588	1566	1587	1597
35	1564	1577	1555	1563	1573	1574	1558	1579	1587
40	1552	1562	1542	1545	1560	1558	1549	1569	1575
45	1548	1548	1530	1538	1548	1549	1526	1547	1566
50	1530	1530	1519	1515	1528	1529	1517	1531	1542
55	1522	1522	1508	1506	1506	1515	1509	1525	1533
60	1509	1516	1503	1494	1496	1502	1500	1514	1511

GT mixtures (m/s)

Temperature ^0C	20 %	15 %	10 %	5%	1%	0.5 %	0.1 %	0.05%	0.01 %
30	1621	1645	1630	1616	1636	1604	1639	1626	1620
35	1613	1626	1622	1607	1625	1600	1622	1613	1611
40	1608	1618	1614	1595	1618	1598	1610	1604	1602
45	1594	1601	1608	1579	1610	1583	1604	1594	1591
50	1587	1588	1601	1556	1602	1571	1591	1584	1579
55	1564	1574	1596	1544	1593	1566	1586	1568	1573
60	1545	1560	1583	1536	1589	1559	1577	1550	1568

Na Alg. mixtures (m/s)

Temperature ^0C	20 %	15 %	10 %	5%	1%	0.5 %	0.1 %	0.05%	0.01 %
30	1584	1596	1599	1579	1595	1575	1569	1591	1588
35	1564	1588	1586	1563	1575	1546	1547	1576	1568

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40	1547	1567	1566	1542	1544	1523	1536	1564	1535
45	1514	1539	1542	1535	1532	1511	1518	1548	1514
50	1494	1528	1533	1528	1515	1506	1509	1537	1500
55	1476	1521	1518	1517	1504	1478	1486	1517	1490
60	1466	1509	1507	1506	1486	1464	1473	1501	1479

CMC mixtures (m/s)									
Temperature ^0C	***20 %***	***15 %***	***10 %***	***5%***	***1%***	***0.5 %***	***0.1 %***	***0.05%***	***0.01 %***
30	1602	1598	1600	1621	1603	1597	1591	1616	1594
35	1594	1590	1588	1614	1596	1576	1571	1611	1588
40	1591	1584	1579	1604	1588	1549	1562	1604	1580
45	1586	1577	1571	1595	1563	1538	1547	1599	1577
50	1575	1560	1563	1580	1541	1526	1536	1591	1563
55	1564	1555	1548	1571	1538	1521	1522	1579	1544
60	1560	1543	1535	1562	1526	1517	1518	1562	1531

MC mixtures (m/s)									
Temperature ^0C	***20 %***	***15 %***	***10 %***	***5%***	***1%***	***0.5 %***	***0.1 %***	***0.05%***	***0.01 %***
30	1586	1593	1601	1603	1585	1590	1607	1587	1605
35	1574	1586	1591	1587	1573	1580	1590	1567	1599
40	1561	1566	1583	1563	1554	1566	1577	1563	1588
45	1545	1547	1576	1551	1538	1544	1561	1545	1553
50	1528	1533	1566	1543	1526	1525	1549	1538	1563
55	1512	1518	1553	1528	1514	1511	1539	1521	1558
60	1508	1509	1538	1517	1503	1501	1526	1514	1542

HPMC mixtures (m/s)									
Temperature ^0C	***20 %***	***15 %***	***10 %***	***5%***	***1%***	***0.5 %***	***0.1 %***	***0.05%***	***0.01 %***
30	1619	1624	1594	1612	1599	1587	1602	1579	1601
35	1606	1612	1563	1604	1586	1575	1590	1570	1589
40	1586	1601	1540	1584	1574	1545	1579	1558	1569
45	1569	1585	1531	1575	1558	1521	1562	1545	1533
50	1555	1573	1520	1553	1533	1509	1546	1529	1520
55	1538	1559	1519	1548	1510	1499	1522	1511	1503
60	1514	1546	1507	1521	1496	1476	1503	1500	1488

7. c.) Effect of temperature on ultrasonic sound velocity of biopolymer mixtures contain Hg metal ion

XG mixtures (m/s)									
Temperature ^0C	***20 %***	***15 %***	***10 %***	***5%***	***1%***	***0.5 %***	***0.1 %***	***0.05%***	***0.01 %***
30	1610	1595	1605	1607	1613	1616	1594	1610	1607
35	1603	1589	1604	1584	1607	1600	1593	1605	1601
40	1597	1584	1599	1574	1576	1589	1570	1595	1600
45	1586	1575	1596	1567	1543	1576	1565	1582	1598
50	1573	1566	1587	1554	1539	1552	1526	1572	1584
55	1560	1548	1562	1543	1526	1543	1508	1568	1580
60	1553	1512	1543	1518	1498	1510	1496	1543	1575
GT mixtures (m/s)									
Temperature ^0C	***20 %***	***15 %***	***10 %***	***5%***	***1%***	***0.5 %***	***0.1 %***	***0.05%***	***0.01 %***
30	1607	1604	1603	1600	1605	1608	1604	1602	1607

35	1600	1588	1581	1596	1596	1591	1601	1590	1604
40	1596	1577	1573	1585	1589	1581	1596	1570	1586
45	1589	1563	1561	1563	1579	1576	1572	1563	1583
50	1580	1553	1537	1546	1543	1557	1529	1552	1561
55	1574	1526	1506	1531	1538	1545	1511	1539	1553
60	1567	1504	1498	1520	1520	1530	1498	1501	1545

3.3. Spectrophotometric study

Solution containing Fe (II) and Hg (II) metal ions with different concentrations of bio-polymers analyzed using Visible Double Beam spectrophotometer. Absorption maximum obtained for different concentrations of biopolymer mixtures. Maximum absorption has obtained at 355nm for all the biopolymer mixtures containing Fe metal ion as well as for blank solution of Fe. Similarly maximum absorption obtained at 491nm for Hg blank also for its XG and GT mixtures. Absorption values, for Fe blank at 355nm is 0.051 and for Hg blank solution at 491nm is 0.504. For every mixture, respective blank reading has taken. Spectroscopic readings for Guar gum, Xanthan gum, Acacia gum, Gum tragacanth, Sodium alginate, CMC, Methyl Cellulose and HPMC mixtures which contain Fe metal ion are shown in Fig.7.a, 7.b, 7.c, 7.d, 7.e, 7.f, 7.g and 7.h respectively. Fig.8.a and 8.b represents spectral readings for XG-Hg and GT-Hg mixtures respectively.

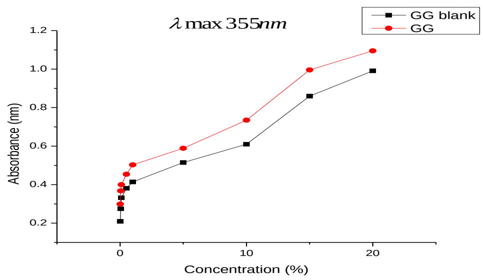

Fig.7.a Spectral readings for GG-Fe mixtures

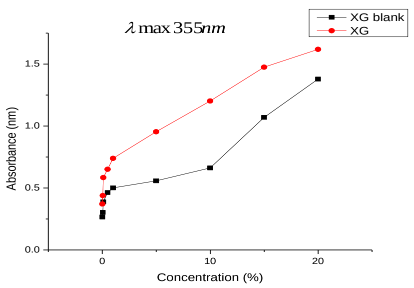

Fig.7.b Spectral readings for XG-Fe mixtures.

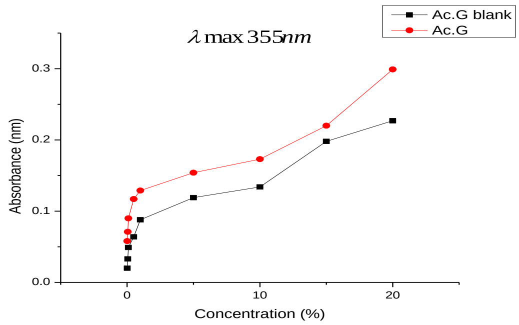

Fig.7.c Spectral readings for Ac.G-Fe mixtures

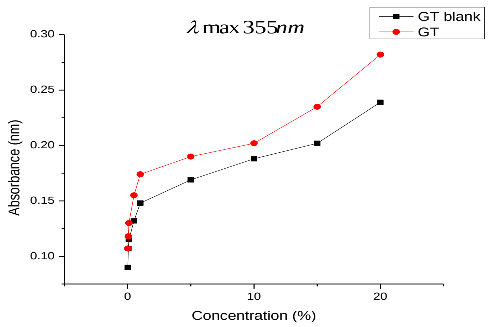

Fig.7.d Spectral readings for GT-Fe mixtures.

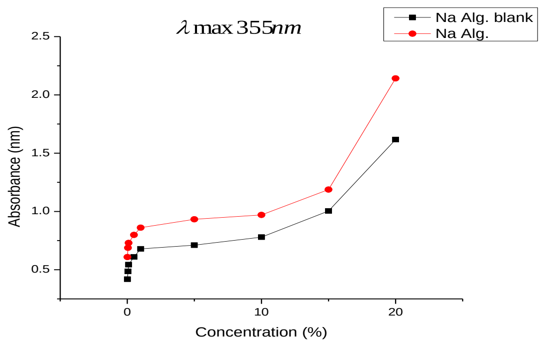

Fig.7.e Spectral readings for Na Alg.-Fe mixtures

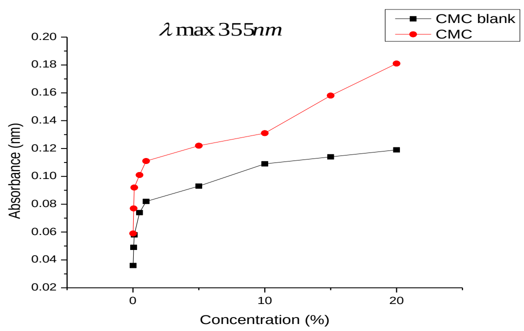

Fig.7.f Spectral readings for CMC-Fe mixtures

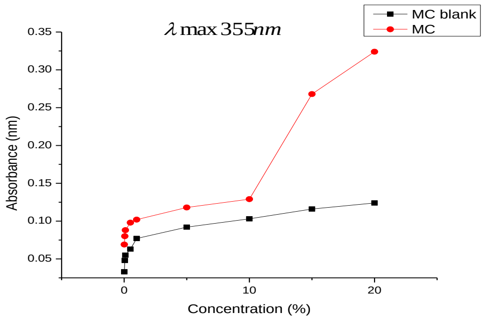

Fig.7.g Spectral readings for MC-Fe mixtures

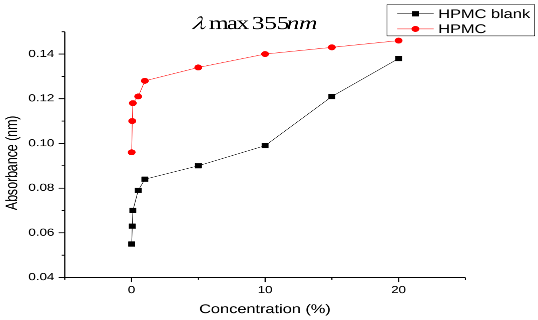

Fig.7.h Spectral readings for HPMC-Fe mixtures

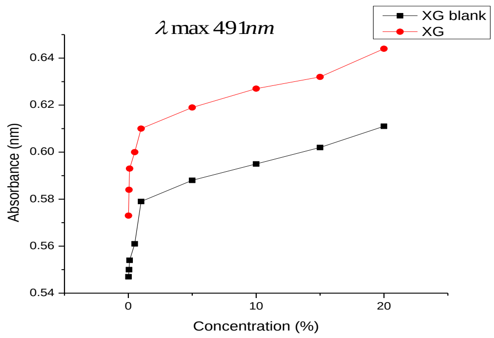

Fig.8.a Spectral readings for XG-Hg mixtures.

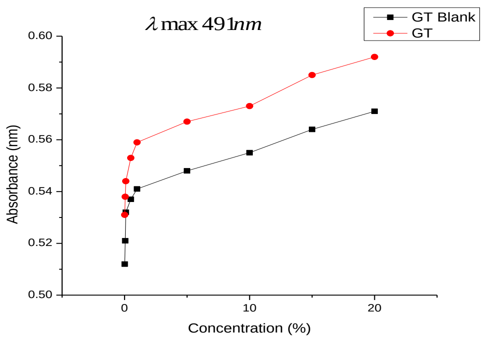

Fig.8.b Spectral readings for GT-Hg mixtures

IV. CONCLUSION

Study has shown that biopolymers such as Guar gum, Xanthan gum, Acacia gum, Gum tragacanth, Sodium alginate, Carboxymethyl cellulose, Methyl cellulose and HPMC mixtures can absorb significant amount of Fe (II) metal ion whereas Xanthan gum and Gum tragacanth mixtures can absorb significant amount of Hg metal ion from industrial waste water. Minimal quantity of biopolymer mixture that is 0.01% or 0.1mg of biopolymer can effectively absorb Fe (II) and Hg (II) metal ions from waste water instead of using large quantity. Sorption kinetics of biopolymers studied at different concentrations at different temperatures. Study revealed that, solution property studies like change pH, viscosity, density, absorption capacity and ultrasonic sound velocity with and without the sorbed metal ions, decreases with increase in temperature. Acidic pH range of 2-3pH noticed throughout in every mixture. Biopolymer mixtures which form very thick with Fe and Hg metal ion solution will have greater density and viscosity values. Remaining mixtures either close to each other or seem to be overlapping. Maximum absorption observed at 355nm for all Fe related biopolymers also for Fe blank. For Hg blank solution, XG-Hg and GT-Hg mixtures absorption maximum obtained at 491nm.

V. ACKNOWLEDGMENT

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