

AN EXPERIMENTAL INVESTIGATION ON TREATMENT OF SEWAGE WATER USING PG α 21Ca

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ABSTRACT: Gamma-polyglutamic acid (γ -PGA) is a polymeric acid containing calcium and aluminium salts in its formulation. The salts in its formulation reacts with soluble metals which has the same content and thus forming polyglutamates. The resulting Polyglutamates are readily settled and they absorb the inorganic substances and thus purifies the contaminated water.

In this study, we have examined the effectiveness of Polyglutamic acid (PGA) in removing the contaminants in water and also reduce pathogens in water supply.

Various methods are employed to treat this effluent, which include the use of rotary vacuum filters; synthetic flocculants (e.g., PAC, PAM) and bio-flocculants (e.g., PGA).

This study is focused on the analysis of the efficiency of PGA, a water purification product, in the treatment of waste water collected from Sewage treatment plants of Doddajala & Chikkajala situated in Rural Bangalore.

Flocculation coagulation method using polyglutamic acid (PGA) was employed to remove the solids from the wastewater. PGA has high flocculation efficiency and is able to flocculate a wide range of organic and inorganic compounds.

INTRODUCTION: A significant environmental issue in India is water pollution and untreated sewage is one of the most contributing factor for water pollution. A few sources of polluted water are agricultural run-off, unregulated small scale industry or other sources of pollution. In India most of the water bodies like rivers, lake and surface water are polluted due to Industries, untreated sewage and solid waste.

A study which was conducted in 2007 found that the single most important source of pollution of surface and groundwater in India is untreated sewage. The problem is not because India does not have sufficient treatment capacity but the problem is also that the existing plants do not operate or are not maintained properly. Due to the factors such as improper design or poor maintenance or lack of reliable electricity supply to operate the plants that are owned by government remain closed. Poor management and absentee employees also are one of the important factor. The waste water generated is either evaporated or normally percolates into the soil. The uncollected waste is then accumulated in urban areas causing unhygienic conditions which leads to releasing pollutants that leach into surface and groundwater.

There are many methods known to human kind to treat waste water and one of the effective method is Polyglutamic acid which has been actively used in treatment of water in countries like Japan, polyglutamic acid has received lot of attention from environmental applications. They can be produced by fermenting soya beans and the bacterium *Bacillus subtilis* found in foods such as Natto, which is considered a dish in Japan.

This polymeric acid reacts with calcium and aluminium salts contained in its formulation, as well as with soluble metals that are present in water forming polyglutamates. The resulting Polyglutamates are readily settled and they absorb the inorganic substances and thus purifies the contaminated water.

Bengaluru is a metropolitan region of Karnataka situated in the southern part and is one of the largest urban acclamtions. Significant problems such as intense urbanisation and economic development has led to various environmental issues for Bengaluru region. Since there is a large amount of demand for water supply in the city, the efficiency of treatment plant also increases and becomes very necessary to be completely and consistently operating. Among the water courses that make up a rural Bengaluru hydrophobic network, Doddajala and Chikkijaala present in northern part of Bengaluru is mostly known for industries and road connections respectively, they have a waste containing high pH coming from the industries and surroundings which is dumped into nearby lake or river causing

hazardous effects on aquatic animals and plants. Treatment of waste water before disposing it off to rivers and lakes is the only solution to avoid hazardous effects.

The two important processes in conventional treatments are coagulation and flocculation. Mixing chemicals such as inorganic coagulants into water under intense agitation which electrically destabilise impurities causing them to agglomerate is known as coagulation. Whereas flocculation, the agitation is slower and longer, adding formation of flocs, which are settled and then removed by filtration, aluminium sulphate and aluminium Polly chloride are the aluminium-based products which are commonly used for coagulation in water treatment plants. These products bear the risk on animals and humans health where they cause appearance of degenerative diseases like Isomers, associated with the use of aluminium salt in water treatment, alternatives to these have been found such as bipolymers. They can either be used in combination or separately between organic Coblentz, thus reducing operational cost, as well as impacts on environment and human health. It has also been evaluated that the efficiency of poly glutamic acid in water treatment plant has been proved to be efficient in removal of turbidity and colour, with little change of PH of the medium, thus providing effectiveness in public water supply treatment.

Gamma polyglutamic acid is water soluble, biocompatible, biodegradable and non-toxic by a polymer obtained from bacteria of bacillus through a fermentive process. From above, the purpose of the study was only to analyse the efficiency of gamma poly glutamic acid in coagulation flocculation process and separation of solids from liquids by sedimentation, in order to reach a standard raw water quality of Doddajala and Chikkajaala, located in rural region of city of Bangalore, Karnataka.

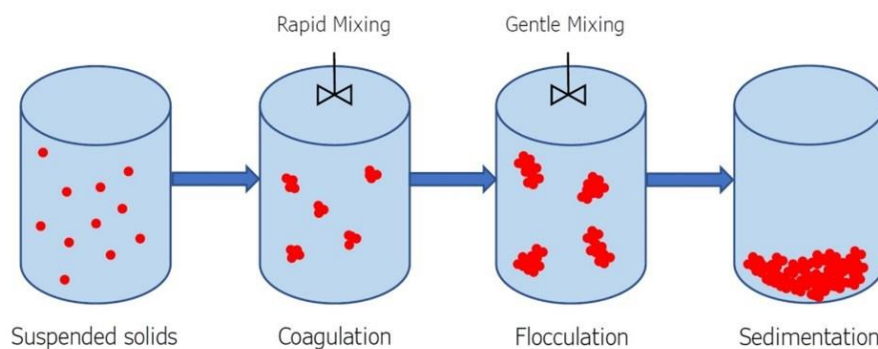


Fig 1. Treatment process

LITERATURE REVIEW:

Chao Zhang [1]: Conducted tests on waste water for removal of Chromium (VI) using Gama-polyglutamic acid. It was observed that *Bacillus subtilis* derived from gamma-polyglutamic acid, had a removal efficiency of 98.7% at 100mg/l initial Cr(VI) concentration, pH2 and 0.1g/l biosorbent. It was also observed that *Bacillus subtilis* have maximum biosorption rate of 48.64% at 100mg/l initial chromium concentration, pH 2, 30 degree Celsius and 2g/l biomass. The above observation shows that *Bacillus subtilis* had a strong adaption capacity for Cr (VI).

Fumihiko Ogata [2]: experiments about the removal of phosphate ions from aqueous solution by using PGAF i.e., Poly-γ-glutamic and flocculants. The removal percentage of phosphate ions by PGAF was 98.2% within 10 min. Hydroxyapatite ($\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$) and calcite (calcium carbonate) were produced by adding PGAF to a phosphate ion solution. By experimenting they also found that when PGAF was added to aqueous solution hydroxyapatite and calcite were produced and XDR pattern was obtained. This experiment was successful for the separation of solid and liquid. The phosphate ions were found to be removed very quickly with 60 - 120 rpm. They found that there was no change in temperature and pH of solution.

Man Djun Lee [3]: conducted a series of experiments to determine the optimum working conditions of PGA in Palm Oil Mill Effluent (POME) treatment. It is found that the optimum pH and dosage of PGA in POME for COD, colour, and TSS removal are at pH 3 and 800ppm. Findings reveal with this condition; the COD removal was up to 45.16%, colour removal up to 77.6%, and 100% TSS removal. Results also showed that PGA is dosage-dependent, which works well in POME under room temperature, and no pH modification is needed.

Sonny S Mark [4]:evaluated polyglutamic acid as a potential biosorbent material for use in the removal of heavy metals from Aqua solutions. Copper was chosen as the model heavy metal used in this study since it is extensively used by electroplating and other industries. Polymer enhanced diafiltration using gamma PGA is a potentially effective means to recover and concentrate divalent cations from dilute aqueous solutions. By circulating the polymer solution through or tangential flow filtration system in a diafiltration or constant volume mode, significant layer of accumulated polymer at the membrane interface is maintained at all times during the process.

Tomokazu Yanagibashi [5]: examined the effect of Poly- γ -glutamic Acid Flocculant (PGAF) on the removal of ultrafinecement (UFC) particles stabilized by a poly-carboxylate co-polymer, which is a superplasticizer (SP). They found that removal efficiency reduced with the increase in the ionic strength, probably because of the shrunk form of poly- γ -glutamic acid(γ -PGA) at high ionic strengths. Their results suggest that PGAF is a good candidate for the purification of cement suspension by flocculation-sedimentation and a better removal performance can be obtained at lower ionic strengths with intense rapid mixing.

Valquíria Campos [6]:analyzed the effectiveness of polyglutamic acid-based bioflocculant in water clarification and purification. The tests were performed using raw water from the Salto de Pirapora Water Treatment Plant in the state of São Paulo, Brazil. In dry season, 80 mg/l of PG α 21Ca removed 89.74% of apparent colour, and residual turbidity was 5.78 NTU. In rainy season, 90 mg/l of PG α 21Ca removed 96.89% of apparent colour and residual turbidity was 1.93 NTU.

Yonghzang, Bo & Yu Zhang [7]: investigates the flocculation performance of polyglutamic acid-based bio flocculant PG α 21Ca by processing kaolin suspension studies the effects on the flocculation efficiency from the amount of flocculant pH temperature hydraulic condition. Influence of the amount of PGA to flocculation, pH, temperature to flocculation has been interpreted in the study. And also, its effects on actual domestic waste water, on algae contaminated lake water, wastewater from beer brewing is discussed. The results conclude that polyglutamic acid is a boiler flocculant with high flocculation efficiency and stable flocculation property. It has much better effects on removal of ammonia nitrogen than PAC, PFS and similar products. The dosage needed and the cost of polyglutamic acid a relatively high which cause high operation cost and limit divide in the applications of PGA.

SCOPE: At present, aluminium derived flocculants such as aluminium sulphate, poly-aluminium chloride (PAC) and synthetic polymer such as polyacrylamide (PAM) are widely used in coagulation treatment. The treatment by using PAM and PAC is relatively cheaper than using biodegradable polymers such as polyglutamic acid in terms of cost. The main disadvantage of using PAM is the effect to the environment and health. PAM itself is non-toxic but the end product of the procedure may produce acrylamide, which is neurotoxin to human and dangerous to the environment. PAC is also used to clean water, but there are some risks associated with its usage, such as the accumulation of the aluminium in the body will lead to Alzheimer's disease and breast cancer. The suspended solid from both PAM and PAC are non-biodegradable and were deemed unsafe to the environment. Among these flocculants, polyglutamic acid (PGA) is considered as the best because of its high yield, high flocculating activity and ability to flocculate a wide range of organic and inorganic compounds.

MATERIALS AND METHOD:

A. SEWAGE SAMPLE

The sewage water samples were collected from the Sewage treatment plants of Chikkajaala & Doddajaala Gram Panchayats, located in Bangalore Urban district of Karnataka. Two samples of 1000 mL were collected to perform the water quality tests in determining the action of Polyglutamic acid in its optimal dosage. Tests such as pH, Turbidity, Color and Chemical oxygen demand was carried out of which the results are discussed.

B. PGα21Ca



Fig 2: PGα21Ca powder

A Multi-Functional High Polymer Flocculant, PGα21Ca (POLY-GLU Social Business Co., Ltd., Osaka, Japan) was used as the flocculant. PGα21Ca is a natural polymer consisting of γ -PGA, which is an amino acid obtained from *Bacillus subtilis*.

PGα21Ca is composed of cross-linked γ -PGA with an average molecular weight of 10^7 and natural minerals such as calcium sulfate and calcium carbonate hydrate. As these minerals are known to promote coagulation through charge neutralization, they can aggregate even when added to pure water. These characteristics make handling easier, allowing direct addition of PGα21Ca powder into water even when treating a small amount of wastewater.

PGα21Ca can be applied at a wide range of pH and is expected to be effective.

The special features of PGA include fast formation of flocs and their fast precipitation, it can also be used for a wide range of pH (4-12) of water. The action of PGA induces only small changes in pH compared to other flocculants. Safety has been confirmed by several examinations at the institutions recognized by environment ministry. It can effectively remove heavy metals in water can reduce cost of sludge treatment since proportion of water influx is quite low. This can be used together with another flocculant such as PAC.

C. PGα21Ca DOSAGE

In order to find the optimum dosage of PGα21Ca to be used, the target wastewater is put into a beaker and then PGα21Ca powder is added to the sewage sample. The sample is stirred sufficiently. The amount of PGA depends on the kind of the target wastewater.



Fig 3: Weighing Balance

The sample water is treated by adding PGCa21 at **50 PPM (0.05g/L)** and the flocculant amount is gradually increased if there is no alteration observed in the sewage sample.

If too much flocculant is added, increased amount of wastewater is added. A few minutes later flock forms and after a short period of time it starts to settle out to the bottom. The clear upper portion of water is utilized for further tests and the precipitates are disposed.

D. TURBIDITY



Fig 4: Turbidity Meter

The turbidity of sample is the reduction of transparency due to the presence of particulate matter such as clay or slit, finely divided organic matter, plankton or other microscopic organisms. These cause light to be scattered and absorbed rather than transmitted in straight lines through the sample. The values are expressed in nephelometric turbidity units (NTU).

The method employed in our case is the **Nephelometric method**. It is based on comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions.

Turbidimeter - The turbidimeter shall consist of a nephelometer with a light source for illuminating the sample and one or more photoelectric detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. The turbidimeter should be so designed that little stray light reaches the detector in the absence of turbidity and should be free from significant drift after a short warm up period.

E. pH

Chemical and biological reactions at sewage works are profoundly influenced by pH. A regular check on the pH of sewage effluent is therefore essential. A pH test will also check, for example, on the effect of acid or alkaline trade wastes in the effluent flow.



Fig 5: pH Meter

pH is measured with **pH meter** with a pH electrode used for pH measurement. The method employed is the **electrometric method**. The pH value is determined by measurement of the electromotive force of a cell consisting of an indicator electrode immersed into the test solution and a reference electrode. Contact between the test solution and the reference electrode is usually achieved by means of a liquid junction which forms part of the reference electrode. The electromotive force is measured with a pH meter i.e., a high impedance voltmeter calibrated in terms of pH.

F. COLOUR

Colour in water may be due to inorganic ions, such as iron & manganese, humus & peat materials, plankton, weeds and industrial wastes. The term 'colour' is used to mean true colour that is the colour of water from which turbidity has been removed. The term apparent colour includes not only the colour due to substances in solution, but, also that due to suspended matter. Apparent colour is determined on the original sample without filtration or centrifugation.

Colour is measured by **visual comparison** of the sample with **platinum-cobalt standards**. One unit of color is, that produced by 1 mg platinum per liter in the form of chloroplatinate ion. It is expressed in **Hazen units**.



Fig 6: Standard solutions used in colour comparison method

G. CHEMICAL OXYGEN DEMAND (COD)

Chemical oxygen demand is a measure of the amount of oxygen required to oxidize all organic material into carbon dioxide and water. COD values usually are higher than BOD values, but COD measurements can be obtained in a few hours while BOD measurements will take around five days.

The COD before and after the experiment was measured according to the method prescribed in **IS 3025 (Part 58): 2006** for the examination of sewage water using Sulphuric Acid Concentrate and Standard Potassium Dichromate (0.25 N) reagents. Instruments like **COD Digesters** and **Temperature Controller** were used in the process.

RESULTS AND DISCUSSION:



Fig 7: Original sample with treated sample

I. Effect of PGαCa21 Dosage on Turbidity

- a) **Doddajaala STP Sample:** At an optimum dosage of 0.35 g/L of PGα21Ca, turbidity which was initially tested to be 110 NTU was reduced to 18 NTU.
- b) **Chikkajaala STP Sample:** An optimal dosage of 0.20 g/L of PGα21Ca, turbidity which was initially tested to be 110 NTU was reduced to 14 NTU.

It can be observed from above results that turbidity of sewage sample after treatment with PGα21Ca satisfies the criteria for standards of drinking water.

II. Effect of PGαCa21 Dosage on pH

- a) **Doddajaala STP Sample:** At an optimum dosage of 0.35 g/L of PGα21Ca, pH is observed to have increased from 7.41 (before treatment) to 7.89 (after treatment) at 24.4°C.
- b) **Chikkajaala STP Sample:** At an optimum dosage of 0.20 g/L of PGα21Ca, pH is observed to have increased from 7.37 (before treatment) to 7.77 (after treatment) at 24.6°C.

From the above results, it can be observed that pH increases exponentially with the addition of PGα21Ca.

III. Effect of PGαCa21 Dosage on Colour

- a) **Doddajaala STP Sample:** In the process of determining the color, it was found that the sample showed the reduction from 90 Hazen units to less than 5 Hazen units after the treatment with PGα21Ca at an optimum dosage of 0.35 g/l.
- b) **Chikkajaala STP Sample:** In the process of determining the color, it was found that the sample showed the reduction from 90 Hazen units to less than 5 Hazen units after the treatment with PGα21Ca at an optimum dosage of 0.20 g/l.

It can be seen from the above results that the colour of the sewage samples are removed completely.

IV. Effect of PGαCa21 Dosage on COD

- a) **Doddajaala STP Sample:** COD which was found to be 216 mg/l before treatment was brought down to 44 mg/l after the treatment with PGα21Ca at an optimum dosage of 0.35 g/l.
- b) **Chikkajaala STP Sample:** COD which was found to be 312 mg/l before treatment was brought down to 32 mg/l after the treatment with PGα21Ca at an optimum dosage of 0.20 g/l.

It has been observed that the COD of the sewage samples collected from STP range from 200 to 350 mg/L, which after treatment is lowered down to the range of 30 to 50 mg/L. Since this range is less than 75 mg/L, the treated water will have minimum pollution potential and can now be safely discharged to natural water bodies.

i. Dodaajala STP sample

	pH	Color	Turbidity	COD
Raw water	7.41	110 NTU	90 Hazen units	216 mg/L
Treated water	7.89	18 NTU	< 5 Hazen units	44 mg/L

ii. Chikkajala STP sample

	pH	Color	Turbidity	COD
Raw water	7.37	110 NTU	90 Hazen units	312 mg/L
Treated water	7.77	14 NTU	< 5 Hazen units	32 mg/L

CONCLUSION: In this study polyglutamic acid natural food-based environment friendly biopolymer is used to treat the sewage water from treatment plants and the performance is measured in terms of COD colour PH and turbidity. The main contribution of this study is to prove that the PGA at its optimal dosage works very efficiently in removing the impurities from the contaminated water. The PGA administers in lowering the characteristics of impure water to such an extent that the contaminated or sewage water after treatment satisfies the criteria required for drinking water purposes. In this study, we found out the optimal dosage of PGA for samples collected from Chikkajaala and Doddajaala STPs as 0.35 g/L & 0.20 g/L respectively. At its optimal dosage, PGA effectively reduces the turbidity of samples by approximately 85%. PGA also helps in the complete removal of apparent color of the samples. We also examined that the effect of PGA in the reduction of

COD and it successfully reduced the COD of the samples by 80-90%, thus making it now suitable to be released to the natural water bodies.

In the process of coagulation flocculation and separation of solids from the liquid phase by settling, PG α 21Ca showed significant results in the removal of apparent color and in the residual turbidity of water samples collected from the sewage treatment plants. However, it should be kept in mind that this product is inorganic and may produce large quantities of raw sludge, which would have to be managed.

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