# COD Reduction from Aminoplast Industry Effluents

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**Summary:** Wastewater from an aminoplast industry located at Industrial Estate Gadoon Amazai was chemically evaluated for parameters like; pH, turbidity, sulphide, suspended solids, chemical oxygen demand (COD), and biochemical oxygen demand ($BOD_5$). It was found that the effluents contain very high COD (23490 – 28410 mg $O_2$/ L) which render it harmful for aquatic life when discharged into the nearby water channels without any treatment. Different physicochemical treatment techniques like air stripping, pH adjustment, flocculation and chemical adsorption were employed at the laboratory scale, which has indicated that more than 80 % COD was reduced by employing the treatment techniques. The results were found promising which suggest that a combined strategy based on the above techniques can be adopted for the treatment of the toxic nature of this industrial effluent. A combined treatment strategy incorporating the results of the present study and the polishing treatment technique is proposed for better results.

## Introduction

The plastic industry is one of the high foreign exchange earning industries in Pakistan, but little attention has so far been paid towards treatment of its effluents. Such untreated effluents result in poisoning the vast land, emission of objectionable odour, deterioration of water quality both underground and subsurface, which directly or indirectly, affects the health of local inhabitants as well as the aquatic life in the receiving water channels. The aminolpast industry use mainly urea, formaldehyde and dyes (additives) as its raw materials which contribute significantly in contaminating the water body during the process.

At present, 90 % of the plastic is exported in powder form. There are presently over 12 aminoplast making industries in the public and private sector. Major clusters of these industries are located in Karachi, Kasur, Lahore, Sheikhupura, Hubb and Gadoon.

Several studies have been made in the past on characterization of industrial effluents and their contribution towards the aquatic pollution. Studies have been carried out on the monitoring of industrial effluents from the industries of different localities of NWFP [1-2]. Similarly Inorganic contaminant in the potable water of Karachi has also been reported [3]. Studies were also undertaken on the environmental impacts of industrial effluents from woolen and sugar mills situated in D. I. Khan [4] that render the potable water unfit for drinking purpose due to contamination from these industries. Wastewaters of tanneries, fertilizers and textile industries in Multan region has also been reported [5] which reveals that the waste from these industries are highly polluted and are hazardous to the mankind and environment. The adverse effects of industrial effluents on soil and vegetation have also been reported [6-7] The pollution of Kabul River by the receiving discharges from the industries located along its way has been discussed [8-9] and it was concluded that Kabul River is no longer fit for drinking due to the indiscriminate discharges of the industrial effluents in the river [10]. The studies have also been undertaken on the textile effluents [11] and it was reported that the discharges from these industries are responsible for reduction of fish population due to the alarmingly high concentration of sulphide in Kabul River.

Studies have been carried out on the development of treatment technologies for the wastewater of different industries. Efforts have been made to detoxify the tannery effluents employing physicochemical followed by biological method [12] whereby the TSS, BOD and COD concentrations were substantially decreased by 98.74 %, 87 % and 81 % respectively. In another study treatment technology has been developed for the treatment of wastewater from sugar industry [13] by which BOD

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and COD concentration in the wastewater has been reduced to 96 % and 95 % respectively. Studies on COD reduction of effluent from cotton textile industry have also been carried out by some authors [14] which shows that an overall COD reduction of 80 % has been achieved using biological treatment technique. Similarly a physicochemical process has been developed for the reduction of excessive fluoride concentration [15] in potable water using indigenous materials. By this process, fluoride concentration in water has been reduced by 86 %. Studies have also been undertaken for the treatment of brewery wastewater treatment using clay and stone pebbles as filtering media in which a substantial decrease in COD content has been observed [16]. Treatment of municipal wastewater in a city of Korea has also been carried out by city government and private sector with the establishment of wastewater treatment plants which played a significant role in the reduction of BOD and COD [17].

The present studies are aimed at to characterize and develop an economically feasible and technically viable method for the treatment of wastewaters from aminoplast industry and to reduce its harmful effects in terms of COD on the nearby water bodies. Devising a treatment technology on the studies undertaken would provide an alternate to industries for the treatment of their high strength organic effluent before discharging them into water bodies.

## Results and Discussions

### *Characterization of Effluents*

The wastewater samples collected were chemically evaluated by the standard methods [18] for the important parameters like pH, Sulphide, Turbidity, Suspended solids, COD and $BOD_5$.The results were compared with the values of NEQS, presented in Table-1.

It has been observed that pH values ranged from 7.5 to 8.5 and the average pH value being 7.95. The $BOD_5$ of the wastewater varied from 0 – 20 mg $O_2$/ L and the average value worked out to be 12 mg/ L. The COD value of the wastewater samples varied from 23490 – 28410 mg $O_2$/ L and the average COD is 26018 mg $O_2$/ L. Due to presence of non-biodegradable organic, biological treatment of such effluent is impossible and only physicochemical treatment is the alternate option.

The National Environmental Quality Standard (NEQS) [19] set by the Govt. of Pakistan recommends a value of pH in the range of 6-10. On this basis, the pH of the combined effluent of the factory is within the permissible range.

The turbidity of wastewater ranges from 140-210 mg/ L which is probably due to the insoluble reactants which make the wastewater turbid when discharged into the drain. Due to high turbidity reduced, high penetration and reduction in the photosynthesis occur which leads to depletion of oxygen in the water bodies.

Due to sulphide discharged from the condensation process, hydrogen sulphide is released at a pH value lower than 6.5. This gas has an unpleasant smell even in trace quantities and is highly toxic to many aquatic species. In higher concentrations, fish mortality may occur. Sulphide in public sewer can pose structural problems due to corrosion by Sulphuric acid as a result of microbial action. The composite wastewater of the factory contains an average of 110 mg/ L (Table-1) whereas the NEQS [19] recommends a value of 1.0 mg/ L.

Suspended solids results in the formation of layer when they settle. The layer so formed on the bottom of the watercourse leads to depletion of oxygen supplies in the bottom of water. The wastewater of the factory contains an average of 485 mg/ l of suspended solids whereas NEQS [19] recommends a value of only 150 mg/ L.

Table-1. Characteristics of wastewater from Aminoplast Industry

| Sample No. | pH | Turbidity | Sulphide (mg/ L) | Suspended solids (mg/ L) | $BOD_5$ (mg $O_2$/ L) | COD (mg $O_2$/ L) |
|---|---|---|---|---|---|---|
| 1 | 8.50 | 180 | 120 | 610 | 0 | 23490 |
| 2. | 7.95 | 170 | 115 | 580 | 10 | 23505 |
| 3. | 7.90 | 160 | 110 | 545 | 15 | 23520 |
| 4. | 8.20 | 155 | 95 | 480 | 12 | 28410 |
| 5. | 7.94 | 160 | 100 | 445 | 13 | 28310 |
| 6. | 8.30 | 175 | 115 | 440 | 8 | 28210 |
| 7. | 7.50 | 180 | 125 | 450 | 9 | 26115 |
| 8. | 8.10 | 200 | 100 | 465 | 12 | 27290 |
| 9. | 7.78 | 210 | 110 | 465 | 12 | 27335 |
| 10. | 7.68 | 180 | 125 | 470 | 13 | 26355 |
| 11. | 7.50 | 175 | 100 | 460 | 10 | 25460 |
| 12. | 7.97 | 150 | 95 | 430 | 20 | 25430 |
| 13. | 8.40 | 145 | 120 | 460 | 12 | 25395 |
| 14. | 7.99 | 140 | 110 | 490 | 12 | 25425 |
| Average | 7.95 | 170 | 110 | 485 | 12 | 26018 |
| NEQS* | 6 - 10 | - | 1.0 | 150 | 80 | 150 |

* National Environmental Quality Standards

BOD is a measure of the oxygen consuming capacity of water containing organic matter. The oxygen content is an essential water quality parameter and its reduction causes stress on the ecosystem. As an example, lack of dissolved oxygen can kill all natural life in water body. The NEQS [19] recommends BOD value is 80 mg $O_2$/ L. The average BOD value as determined from the laboratory investigations is 12 mg $O_2$/ L which lies with the permissible range. The BOD of this high strength wastewater is low due to toxic nature of the wastewater. This shows the low biodegradability of the wastewater.

The COD is a measure of oxygen equivalent to the portion of the organic matter in a sample, which is susceptible to oxidation by a strong chemical oxidant. It is an important parameter for stream and industrial wastewater studies and for control of waste water treatment plants. The average value of COD as worked out in the laboratory for the present investigations ranges from 23490 – 28410 mg $O_2$/ L, as shown in Table-1. According to the NEQS [19], a value of 150 mg $O_2$/ L has been recommended for COD. Hence this specific wastewater is carrying more than 200 times more pollution load in terms of COD.

*Treatment of Wastewater*

The industrial wastewater from aminoplast industry is highly polluted with COD due to the presence of non-biodegradable organic matter. The pollution parameters which require attention for the treatment and disposal of this wastewater are mainly COD. BOD of the effluent is not very high due to presence of toxic and non-biodegradable constituent of aldehyde (Formalin). Treatment like air stripping, pH adjustment, flocculation and chemical adsorption result in a reduction of 80 % of COD in the factory wastewater.

The following techniques have been applied for the treatment of the toxic industrial wastewater of aminoplast industry.

*Air-Stripping*

Air stripping was carried out for an extended period owing to the specific nature of aminoplast effluents. The data related to air stripping are given in Table-2.

High and vigorous aeration was carried out in the tank for formalin (aldehyde) compound. Internal aerators were used for diffused and vigorous aeration during several experiments for different time intervals. It was observed that an optimum of 15 min aeration of the effluents is enough for the reduction of COD to an average of 35.75 %. The results of aeration have been tabulated in Table-2.

*pH Adjustment*

pH adjustment is another method, used for the removal of COD. By this technique substances which are not easily volatile at normal pH are made volatile and allowed to escape from liquid. Some of the substances are volatile at lower pH while others at higher pH. Therefore this step was employed as one of the treatment strategy. It was observed that at pH 9.0, COD was decreased to an average of 24 % and NaOH solution was used for this purpose. The results are presented in Table-3.

*Flocculation*

It is, regarded as a slow mixing technique which permits agglomeration of non-stable particles. One of the most effective coagulant which is universally used for flocculation is alum (Aluminum sulphate). The optimum dose ranges between 5-20 ppm. Different doses of alum were used to obtain the optimum doze of alum for the treatment process. COD removal by flocculation was made and the results are given in Table-4.

Table-2. COD reduction by employing air stripping*

| S. No. | COD reduction | | |
|---|---|---|---|
| | COD (mg $O_2$/ L) Before air stripping | COD (mg $O_2$/ L) After air stripping | % COD Reduction |
| 1. | 27600 | 18400 | 33% |
| 2. | 27250 | 17300 | 36% |
| 3. | 27080 | 16910 | 37% |
| 4. | 28200 | 17800 | 37% |

* after 15 minutes aeration

Table-3. COD reduction with pH adjustment*

| S. No. | COD (mg $O_2$/ L) Before pH Adjustment | COD reduction COD (mg $O_2$/ L) After pH Adjustment | % COD Reduction |
|---|---|---|---|
| 1. | 6415 | 4415 | 28 % |
| 2. | 6090 | 3980 | 20 % |
| 3. | 6045 | 3540 | 25 % |
| | Average COD reduction (%) | | 24 % |

* pH adjusted at 9.0

*Chemical Adsorption*

The following substances were used as chemical adsorbents;

1. Bentonite
2. China clay
3. Charcoal (activated)

No promising results of adsorption with bentonite and China clay were found. ≥ 0.05 % of activated charcoal was used for the industrial effluent. Appreciable decrease in COD (78-88 %) was achieved in individual trials using influent COD in the range of 1584-2544 mg $O_2$/ L (Table-5).

*Combined Chemical Treatment Strategy*

The layout of the combined chemical treatment techniques that would be adopted at the industrial level would be as follows;

By combining the above layout, the wastewater COD would be brought down to more than 80 %. Some dilution would also be required to meet the NEQS permissible limits.

**Experimental**

Fourteen wastewater samples were collected from the aminoplast industry with different interval of time. The samples were chemically evaluated [18]. Standard methods [18] were employed in all determinations. pH was measured with a Metler Delta-320 pH meter. Turbidity was determined by using turbidity meter (Cyberscan WL Turbidimeter TB 1000 USA). Sulphide was determined by titrimetric method [16]. Suspended solids were determined by filtering an aliquot of sample through Whatman-42 filter paper followed by drying it alongwith its contents at 105 °C. Total dissolved solids were determined in the filtrate by evaporating the liquid on a water bath and then drying in an oven at 180 °C.

$BOD_5$ in wastewater samples were determined by finding out the difference between the initial and final dissolved oxygen (DO) concentration after incubation at 20 °C for 5 days divided by the decimal fraction of sample. BOD bottles of 300 mL were used for this purpose. DO levels were measured by Winkler's Azide modification method [16]. Appropriate aliquot of sample was used and suitable dilutions were made where needed. Dilution water was aerated for about 1 h before use.

Table- 4. COD reduction by using flocculation technique

| S. No. | COD (mg $O_2$/L) before flocculation | COD reduction COD (mg $O_2$/L) after Flocculation | % COD Reduction |
|---|---|---|---|
| 1. | 2700 | 1584 | 38% |
| 2. | 2880 | 1800 | 34% |
| 3. | 2800 | 1850 | 34% |

As indicated in Table 4, flocculation has decreased COD of the effluent by an average of 35.33%.

Table-5. COD reduction by adsorption technique using activated charcoal

| S. No. | COD (mg $O_2$/L) before chemical adsorption | COD reduction COD (mg $O_2$/L) after chemical adsorption | % COD Reduction |
|---|---|---|---|
| 1. | 1584 | 333 | 78% |
| 2. | 1584 | 320 | 80% |
| 3. | 2544 | 315 | 88% |
| 4. | 2350 | 270 | 88% |

COD of samples was measured by open reflux method [18]. For this purpose, an aliquot of sample was digested in strong acidic environment ($H_2SO_4$ reagent) in the presence of standard $K_2Cr_2O_7$ solution and digesting the solution for 2 h. The sulphuric acid reagent contained mercuric sulphate and silver sulphate was used to catalyse the oxidation of organic matter in the sample. After digestion, the un-reacted $K_2Cr_2O_7$ was titrated against standard ferrous ammonium sulphate solution using ferroin indicator. A blank was also run in parallel. Ferrous ammonium sulphate solution was standardized on the same day when COD was carried out owing to its oxidation and its subsequent decrease in concentration with the course of time.

*Treatment Methodology*

Keeping in view the above mentioned parameters, the following techniques have been applied for the treatment of the toxic industrial wastewater of aminoplast industry.

Effluents from aminoplast industry at Gadoon Amazai Peshawar (Pakistan) were subjected to different treatments. The aeration of the wastewater is done using internal aerators at different time intervals. After aeration the COD is further reduced by pH adjustment. pH of the wastewater is adjusted to 9.0 slowly and gradually using NaOH solution. The flocculation is carried out using Alum (Aluminum Sulphate). Different doses of Alum was tried to obtain the optimum dose for the treatment process which was obtained by Jar test in the

laboratory. After flocculation, the wastewater was further treated by chemical adsorption by using Charcoal as an adsorbent. The effluent was passed through charcoal in a column of 1L capacity at the initial stage. Lastly the effluent is further diluted adding distilled water at laboratory scale.

## Conclusions

Aminoplast industry effluents were characterized and the organic carbon (a major cause for depletion of dissolved oxygen) discharged into water bodies, was evaluated in terms of $BOD_5$ and COD besides other parameters. The results have indicated that the organic matter contributes more as a pollutant in the industrial wastewater of aminoplast industry in terms of chemical oxygen demand (COD).

On the basis of the laboratory scale studies, the extent of pollution due to factory effluent of aminoplast was decreased and economically viable method of treatment has been developed. Laboratory scale results have indicated more than 80 % COD removal. The results were found promising which suggest that a combined strategy based on the above techniques can be applied onsite for the treatment of the toxic nature of this industrial effluent so as to safeguard the environment from the harmful effects of such hazardous industrial effluents.

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