Perhaps the greatest obstacle to effective environmental protection is the lack of said information — CAROLS CELSO
DO AMAEL SILVA BRAZIL

CHAPTER 3

EFFLUENT - EFFLUENT INTERACTIONS: STUDY OF SOME TERNARY CASES

- ROLE OF GALVANISING LIQUOR
- ROLE OF ALUM LIQUOR
- SYNERGISTIC EFFECTS OF THE LIQUORS
3.1 STUDY OF THE CORRECTIVE INFLUENCE OF GALVANIZING PLANT EFFLUENT IN TERNARY COMBINATIONS OF EFFLUENTS

INTRODUCTION

Industrial effluents are known for certain prominent features associated with them (1,2). The prominent features may include high acidity, high alkalinity, high TDS, high COD, high presence of multivalent metal ions such as Fe$^{3+}$ etc. If placed in selected combinations, these effluents have high potentialities of chemical interactions which may result in total or significant removal of many toxic characteristics of the interacting effluents by the simple act of their mixing together in correct sequence and ratio, provided the industrial units discharging these effluents have the advantage of being located in close proximities. In the work described here, four ternary combinations, out of a total of six selected industrial effluents, have been investigated to evaluate the net improvements in the qualities of the combinations of the effluents in terms of recognised parameters such as pH, TDS, conductance, ORP, COD, Ca-hardness, Mg-hardness, dissolved iron, chloride and sulphate. The guiding principle in selecting the combinations was that any two different effluents known for their high TDS and COD values could be first mixed together so as to produce an equilibrium pH of the mixture in the range of 7.5 - 8.5. This mixture was then made to interact with another effluent known to possess dissolved multivalent ions such as Fe$^{3+}$ or Al$^{3+}$ ions in acidic medium to produce equilibrium pH of the ternary mixture in the range

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of 5.5 - 7.0. Under these conditions, the dissolved multivalent metal ions undergo hydrolysis, and the hydrolysis products play their normal roles in the removal of several dissolved species through the process of surface absorption (3).

The ternary combinations of effluents made and studied here are: (1) Textile Mill effluent (pH 10.64) + Rice Mill effluent (pH 5.14) + Galvanizing plant effluent (pH 2.30). (2) Soap Plant effluent (pH 11.64) + Distillery effluent (pH 4.40) + Galvanizing plant effluent (pH 2.30). (3) Soap plant effluent (pH 11.64) + Phosphatic fertilizer plant effluent (pH 1.40) + Galvanizing plant effluent (pH 2.30). (4) Textile mill effluent (pH 10.64) + Distillery effluent (pH 4.40) + Galvanising plant effluent (pH 2.3). Two sets of each ternary combinations were prepared. These two sets were obtained at equilibrium pH of 7.00 and 5.50. These sets at different pH values are obtainable by controlling the addition of galvanizing plant effluent through pH-monitoring. The sets at pH 7.00 in each combination provided the results of interactions under the conditions of exact neutrality. The sets at pH of 5.50 indicated the additional benefits, if any, arising through the addition of the slight excess of the galvanizing plant effluent.

In the effluent - effluent interactions studied here, the galvanizing plant effluent has been used as a reactant common to each of the ternary mixtures. It would be helpful, therefore, to have an appraisal of the general availability of this effluent. Out of the estimated total zinc consumption of one lakh tonnes in India (1981-82 figure), the galvanization industry's share was estimated at 63,000 tonnes of the metal (4). The zinc consumption for 100 tonnes of steel galvanized was found to be 6.5 tonnes in India (5). The output of the galvanized products per year can be visualized from these figures.
The effluents generated at the galvanization plants are generally the intermix of two types of discharges from the plant. The first type resulted from washing, rinsing and cooling processes, and was almost regular in flow rate. The second type of discharge was that of the pickle liquors which took place when their baths were emptied for rejection of the liquors after they assumed the limiting concentration of dissolved iron (6). This discharge is periodic in nature. The volume ratios between the two types were found varying from 1600:1 to 8000:1 depending on the nature of the products galvanized. The quantum of discharge of the effluents of the four galvanization plants located at Raipur and Bilai areas have been reported in the range 5-300 m$^3$/day (7).

The other effluents which have been used here for interaction with the galvanizing plant effluent are: Phosphatic-fertilizer plant effluent, rice mill effluent, distillery effluent, soap plant effluent and textile mill effluent. The quantum of discharge (m$^3$/day) of these effluents has been found as follows: Phosphatic fertilizer plant effluent-227.7, rice mill effluent- 4/100 bags of rice, Distillery effluent-33.3, Soap plant effluent- 0.7, and Textile mill effluent-900.0. The salient details of these effluents with regard to their genesis and characteristics have been described earlier (Section 1.2). The flow sheet diagrams of phosphatic fertilizer plant, rice mill and textile mill, showing the process details of the respective industries, have been shown in Figs. 3-1, 3-2 and 3-3 respectively.

**MATERIALS AND METHODS**

**Sample Collection**: Samples of industrial effluents (2.5 litres each), in their untreated forms, were collected from galvanization plant (at Bilai), phosphatic fertilizer plant (at Kumhari), rice mill (at Gondia), distillery (at Kumhari), soap plant (at Gondia), and textile mill (at Rajnandgaon).
FIG. 3-1. FLOW CHART FOR TRIPLE SUPER PHOSPHATE PROCESS

- Water
- Wet scrubber
- Waste
- Cyclone
- Mill
- Screens
- Fines
- Bulk storage
- Bagging
- Shipping
- Phosphate rock
- Water
- Steam
- Acid preheater
- Cooler
- Granulator
- Cooler
Fig. 3-2: Flowsheet diagram of a parboiled rice plant.
FIG 33 FLOW CHART INDICATING THE PROCESSES CARRIED OUT AND EFFLUENT STREAMS IN A COTTON TEXTILE MILL
Characterization of effluents: The general physico-chemical characteristics (pH, TDS, conductance, ORP, COD, Ca-hardness, Mg-hardness, chloride and sulphate) were experimentally determined in each sample by standard procedures (4). The dissolved iron in the samples was determined spectrophotometrically using potassium thiocyanate reagent (5). The details of these procedures have been described earlier (Section 2.1). The results obtained have been shown in Table 3-1.

Preparation of binary mixtures: Four binary mixtures (each of a total volume of 500 mL), using the collected samples of industrial effluents (except the galvanizing plant effluent), were prepared as follows: (i) Textile mill effluent + Rice mill effluent, giving an equilibrium pH 7.75. (ii) Soap plant effluent + Distillery effluent, giving an equilibrium pH 7.86. (iii) Soap plant effluent + Phosphatic fertilizer plant effluent, giving an equilibrium pH 8.55. (iv) Textile mill effluent + Distillery effluent, giving an equilibrium pH 8.22. The ratios in which the component-effluents were mixed were recorded, and shown in Table 3-1.

Preparation of Ternary mixtures (pH 7.00): Aliquots (250 mL each) of each binary mixture were placed in beakers, and were made to interact with galvanizing plant effluent added through a burette. The pH of the magnetically stirred mixtures was measured at each addition. The additions were continued till an equilibrium pH 7.00 was obtained in each case. The volumes of galvanizing plant effluent used in each mixture were recorded. The volume ratios between the three components in each ternary mixture have been shown in Table 3-1.

Preparation of ternary mixtures (pH 5.50): Aliquots (250 mL each) of the binary mixtures were made to interact with the galvanizing
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Effluent used</th>
<th>Ratios (v/v) of effluents in the Mixtures</th>
<th>Physico-chemical characteristics found</th>
<th>% removal***</th>
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<tr>
<td></td>
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<td></td>
<td>pH</td>
<td>TDS mg/L</td>
</tr>
<tr>
<td>8</td>
<td>S.No 5 + S. No. 4 + S. No. 1</td>
<td>6.942 : 13.50% : 1.000</td>
<td>7.00</td>
<td>680.84</td>
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<tr>
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<td>% removal***</td>
<td>56.9</td>
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<tr>
<td>9</td>
<td>S.No 5 + S. No. 2 + S. No. 1</td>
<td>7.075 : 2.35% : 1.000</td>
<td>7.00</td>
<td>7255.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>% removal***</td>
<td>94.0</td>
</tr>
<tr>
<td>10</td>
<td>S.No 6 + S. No. 4 + S. No. 1</td>
<td>11.764 : 6.25% : 1.000</td>
<td>7.00</td>
<td>11900.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>% removal***</td>
<td>86.0</td>
</tr>
</tbody>
</table>

Nil denotes undetectable.

** Corresponds to the total values of the three components in the ratios in which they were mixed.

*** Order of mixing in each ternary mixture is the same in which the component-effluents have been described.
plant effluent in a manner described above till an equilibrium pH 5.50 was obtained in each case. The volumes of galvanizing plant effluent used in each mixture were recorded.

The volume ratios between the three components in each ternary mixture have been shown in Table 3-1.

**Characterization of Ternary Mixtures:** The ternary mixtures prepared as above were kept overnight, and then filtered. The general physico-chemical characteristics (pH, TDS, conductance, ORP, COD, Ca-hardness Mg-hardness, chloride and sulphate) were determined by standard procedures (4). The dissolved iron in each mixture was determined spectrophotometrically (5). The results obtained have been shown in Table 3-1. The total values of the respective parameters for each ternary mixture were calculated using the known values of the respective parameters of the effluents and the ratios in which the effluents were mixed in each ternary mixture. The percent removal of the selected parameters (TDS, COD, Ca-hardness, Mg-hardness, dissolved iron, chloride and sulphate) were calculated using the calculated and observed values. The results obtained have been shown in Table 3-1.

**RESULTS AND DISCUSSION**

The results obtained (Table 3-1) provided the following informations: (i) COD which is the key-parameter to indicate the pollutional load of an effluent was removed in all the ternary combinations to extents ranging from 67.8% to 96.9%. (ii) The TDS values similarly were reduced up to the extents ranging from 38.3% to 94.0% in the combinations of the effluents studied here.
(iii) Even the ionic species (chloride, sulphate, Ca-hardness, Mg-hardness) which are not of hazardous nature were found removed up to extents from 20% to 100%. (iv) On comparison of the removal data obtained at pH 7.00 and pH 5.50, it was found that at pH 7.00, the extents of removal of the TDS and COD values were marginally higher in all the cases compared to those at pH 5.50. The removal of the ionic species was, however, found to be higher at pH 5.50 in some combinations. The dissolved iron indicated a higher presence in all the combinations at pH 5.50 compared to that at pH 7.00. On overall basis, the interactions at the equilibrium pH 7.00 appeared to be more advantageous. (v) The excessive alkalinites associated with the soap plant and textile mill effluents, and the excessive acidities associated with the galvanizing and the phosphatic fertilizer plants effluents were all found destroyed during the interaction process, and the pH values of the ternary mixtures were found to be within the limits prescribed as per Indian Standards (6). (vi) The indispensability of an effluent such as that from a galvanizing plant in adapting the interaction technique speaks about a limitation of this technique. However, other effluents such as those from alumina plant, and alum manufacturing plant which both contained high loads of dissolved aluminum suggest their effectiveness if used in place of galvanizing plant effluent.

The concept of effluent-effluent interactions for pollution abatement holds high promise if industrial units discharging the effluents are located in close proximities, share the informations among themselves with regard to the nature of their discharged effluents, and strike out a treatment strategy which would require only a diversion of their respective effluent either in part or full to a common holding tank of the effluents made jointly for this purpose.
3.2 COMBINATION OF GALVANIZING LIQUOR AND ALUM PLANT LIQUOR: ITS APPLICATION IN COD REMOVAL OF ALKALINE EFFLUENTS

INTRODUCTION

Metal ions such as those of Fe(II)/Fe(III) and Al(III) are well known for their coagulating properties. The compounds containing these ions have been widely used in the treatments of waste waters and municipal supply waters (1,2,8), as described earlier (Sections 1.1 and 1.2). The waste liquors containing these ions when used in the treatments of a variety of industrial effluents have been found to give highly favourable results, besides providing substantial economy in the treatment methodologies. The waste liquors containing dissolved iron and aluminum which have been identified here are the galvanizing plant liquor and the alum plant liquor which contain up to 5.20 g/L of dissolved iron (9) and 1.92 g/L of dissolved aluminum respectively. Both of these liquors when made to interact singly with high COD effluents such as those from soap plant, textile mill, copper ore-concentrate plant, and milk processing plant have been found to yield highly satisfactory results in terms of the overall improvements in the physico-chemical characteristics of the combinations of the mixing components (Sections 1.1 & 1.2). In the work reported here, the gain arising from the combined presence of the dissolved iron and aluminum in the COD removal from some high COD effluents has been studied. For this purpose, a mixture (1:1, v/v) of the

galvanizing liquor and the alum liquor was made to interact with selected high COD effluents such as from soap plant, textile mill, copper ore-concentrate plant, and milk processing plant, producing an equilibrium pH 7.00 in each case. The COD values determined in each ternary combination were compared with the COD values which were obtained when the galvanizing liquor and the alum plant liquor reacted singly with the respective effluents. The status of other characteristics (TDS, Conductance, ORP, Ca-hardness, Mg-hardness, dissolved Fe/Al, chloride and sulphate) was also studied in each ternary combination of the effluents.

MATERIELS AND METHODS

Sample Collection: The samples of the waste liquors (2.5 litres each) were collected from a galvanizing plant at Bhilai, and alum manufacturing plant at Kumhari (Distt. Durg, M.P.). The samples of the high COD effluents (2.5 litres each), in their untreated forms, were collected from a soap plant at Gondia, textile mill at Rajanandgaon, copper ore concentrate plant at Malanjhkhand, and milk processing plant at Kumhari. The samples collected earlier (Sections 2.1 and 2.2) have been used for studies here.

Characterization of the effluents: The physico-chemical characteristics (pH, COD, TDS, conductance, ORP, Ca-hardness, Mg-hardness, chloride and sulphate) were determined in each effluent by standard procedures (4). The iron was determined titrimetrically in the galvanizing liquor, and spectrophotometrically in the high COD effluents (5). Aluminum was determined gravimetrically in the alum plant liquor (5). The details of the procedures have been described earlier. The samples and the characterization data are the same which were used earlier and described in Tables 2-1 and 2-2.
Application of galvanizing liquor in COD removal: Aliquots (100 mL each) of the high COD effluents from soap plant, textile mill, copper ore plant, and milk processing plant were taken separately in beakers, and titrated pH-metrically with the galvanizing liquor placed in a burette till an equilibrium pH 7.00 of the mixtures was obtained. The contents were magnetically stirred during the titration. The mixtures were kept overnight, and the COD values determined in each case by the standard procedure (4), after the filtration of the mixtures. The ratios (v/v) between the components used in each mixture, and the COD values obtained have been shown in Table 3-2. The effluents used here were the same used earlier (Sections 2.1 & 2.2). The COD removal data are the same as shown in Table 2-1.

Application of alum plant liquor in COD removal: Aliquots (100 mL each) of the high COD effluents stated above were taken separately in beakers, and titrated pH-metrically with the alum plant liquor placed in a burette till an equilibrium pH 7.00 of the mixture in each case was obtained. The contents were magnetically stirred during the titrations. The mixtures were kept overnight, and the COD values determined in each mixture by standard procedure (4), after the filtration of the mixtures. The ratios (v/v) between the components in each mixture, and the COD values obtained have been shown in Table 3-2. The same effluents which were described earlier (Sections 2.1 & 2.2) have been used here. The COD removal data are the same as shown in Table 2-2.

Application of mixture (1:1 v/v) of galvanizing liquor and alum plant liquor in COD removal: A mixture (1:1 v/v) of galvanizing and alum plant liquors was first prepared. Aliquots (100 mL each) of the high COD effluent stated above were placed separately in beakers, and the
### Table 3-2 Characteristics and Reactability Data of High COD Effluents

<table>
<thead>
<tr>
<th>S. No</th>
<th>Effluent used</th>
<th>Ratios (v/v) of effluents in the Mixtures</th>
<th>pH</th>
<th>COD mg/L</th>
<th>TDS mg/L</th>
<th>Conductance mS/cm</th>
<th>ORP mV</th>
<th>Carboxylate Mg-Ca-CO₃ mg/L</th>
<th>Dose Fe-Al mg/L</th>
<th>Chloride mg/L</th>
<th>Sulphate mg/L</th>
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</thead>
<tbody>
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<td>1</td>
<td>Goudamangar Plant Effluent</td>
<td></td>
<td>7.90</td>
<td>7365.0</td>
<td></td>
<td></td>
<td>-</td>
<td>52.0</td>
<td>170.0</td>
<td>7.75</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alam Plant Effluent</td>
<td></td>
<td>7.10</td>
<td>280.0</td>
<td></td>
<td></td>
<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>3</td>
<td>Soap Plant Effluent</td>
<td></td>
<td>7.30</td>
<td>2544.0</td>
<td></td>
<td></td>
<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>4</td>
<td>Textile Mill Effluent</td>
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<td>2544.0</td>
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<td></td>
<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
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<tr>
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<td>-</td>
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<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
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<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>7</td>
<td>S No. 1 + S No. 3</td>
<td></td>
<td>7.30</td>
<td>2544.0</td>
<td></td>
<td></td>
<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>8</td>
<td>S. No. 2 + S. No. 3</td>
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<td>2544.0</td>
<td></td>
<td></td>
<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
<tr>
<td>9</td>
<td>S No. 1 + S No. 2 + S No. 3</td>
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<td>7.30</td>
<td>2544.0</td>
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<td>-</td>
<td>97.0</td>
<td>15.0</td>
<td>78.9</td>
<td>20.4</td>
</tr>
</tbody>
</table>

*Order of mixing in each ternary mixture is the same in which the component-effluents have been described.

**Corresponds to the total values of the three components in the ratios in which they were mixed.

***N/d denotes undetectable.
TABLE 3-2 (contd...)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Effluent used</th>
<th>Retention (vol) of effluents in the mixture</th>
<th>pH</th>
<th>COD mg/L</th>
<th>TDS mg/L</th>
<th>Conductance (µS/cm)</th>
<th>ORP mV</th>
<th>Ca carbonate (mg/L)</th>
<th>Mg carbonate (mg/L)</th>
<th>Ca hardness</th>
<th>Mg hardness</th>
<th>Diss. Fe/Al mg/L</th>
<th>H₄SΟ₄ mg/L</th>
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<td>10</td>
<td>S No 1 + S No 4</td>
<td>1:1.5465</td>
<td>7.01</td>
<td>1664.0</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
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<td>...</td>
<td>...</td>
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</tr>
<tr>
<td>11</td>
<td>S No 2 * S No 4</td>
<td>1:2.460</td>
<td>7.00</td>
<td>1166.0</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
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<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>12</td>
<td>S No 1 + S No 2 + S No 4</td>
<td>1:1:27.777</td>
<td>7.00</td>
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<td>480.0</td>
<td>1.70</td>
<td>116</td>
<td>89.0</td>
<td>30.0</td>
<td>Fe-16.2</td>
<td>Al-9.3</td>
<td>607.7</td>
<td>148.4</td>
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<td>...</td>
<td>...</td>
<td>...</td>
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<tr>
<td>15</td>
<td>S No 1 + S No 2 + S No 5</td>
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<td>7.00</td>
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<td>Fe-0.6</td>
<td>Al-Ni***</td>
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**% removal**

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<tr>
<th>S. No.</th>
<th>Effluent used</th>
<th>Retention (vol) of effluents in the mixture</th>
<th>pH</th>
<th>COD mg/L</th>
<th>TDS mg/L</th>
<th>Conductance (µS/cm)</th>
<th>ORP mV</th>
<th>Ca carbonate (mg/L)</th>
<th>Mg carbonate (mg/L)</th>
<th>Ca hardness</th>
<th>Mg hardness</th>
<th>Diss. Fe/Al mg/L</th>
<th>H₄SΟ₄ mg/L</th>
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<tr>
<td>16</td>
<td>S No 1 + S No 2 + S No 4</td>
<td>1:1:27.777</td>
<td>7.00</td>
<td>1570.4</td>
<td>480.0</td>
<td>1.70</td>
<td>116</td>
<td>89.0</td>
<td>30.0</td>
<td>Fe-16.2</td>
<td>Al-9.3</td>
<td>607.7</td>
<td>148.4</td>
</tr>
</tbody>
</table>

Contd...

Order of mixing in each ternary mixture is the same in which the component-effluents have been described.

* Corresponds to the total values of the three components in the ratios in which they were mixed

** Nil denotes undetectable.
TABLE 3-2 (contd.)

<table>
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<th>Ratio of each effluent in the Mixtures</th>
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<th>COD (mg/L)</th>
<th>TDS (mg/L)</th>
<th>Conductance (µS/cm)</th>
<th>ORP (mV)</th>
<th>Ca hardness (mg/L)</th>
<th>Mg hardness (mg/L)</th>
<th>DO (mg/L)</th>
<th>Fe (%)</th>
<th>Al (%)</th>
<th>Ni (%)</th>
<th>Cl⁻ (mg/L)</th>
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<td>20.00</td>
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<td>-</td>
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<tr>
<td>17</td>
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<td>7.00</td>
<td>20.00</td>
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<tr>
<td>18</td>
<td>S. No 1 &amp; S 2</td>
<td>1:1 333,333</td>
<td>7.00</td>
<td>102.0</td>
<td>349.8</td>
<td>1.49</td>
<td>139</td>
<td>152.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>197.5</td>
<td>55.8</td>
</tr>
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</table>

**Synergistic gain (%) in COD removal**

|                | - | 3.6 |

Order of mixing in each ternary mixture is the same in which the component effluents have been described.

*Corresponds to the total values of the three components in the ratios in which they were mixed.

*Nil denotes undetectable.
contents were titrated pH-metrically with the mixture of the liquors placed in a burette. The contents were stirred magnetically during the titrations. The addition of the mixture of liquors was continued till an equilibrium pH-7.00 of the mixtures was obtained. The mixtures were then kept over night, and thereafter filtered. The physico-chemical characteristics (COD, TDS, conductance, ORP, Ca-hardness, Mg-hardness, chloride and sulphate) were determined in each mixture by standard procedures (4). Iron and aluminum in each mixture were determined spectrophotometrically using thiocyanate and aluminon reagents respectively (5). The ratios (v/v) between the components in each ternary mixture, and the values of the physico-chemical characteristics found experimentally have been shown in Table 3-2.

RESULTS AND DISCUSSION

The results obtained (Table 3-2) show that the highest synergistic gain (18.2%) was obtained when the dissolved iron and aluminum interacted combinely with the copper ore-concentrate plant effluent. The COD removal in the combined case was found to be 96.2% compared to 56.0% and 93.2% when this effluent was treated singly with each of the liquors. 1 mL each of the galvanizing liquor and the alum plant liquor was found to interact effectively with 71.4 mL and 250.0 mL of the copper ore effluent respectively. The same volume (1mL + 1mL) of the respective liquors in their mixture was found to interact effectively with as much as 666.6 mL of the same copper ore effluent. The combination of the two liquors has thus provided a higher output in addition to a higher removal of the COD. In the case of the soap plant effluent, a synergistic gain of 15.7% in the COD removal was observed. The difference in the output was, however, found to be only marginal in this case. With the milk processing plant effluent, the gain was 3.6%, but the increase in the output in terms of the volumes
of the treatable effluent was quite large. The synergistic gain in the case of textile mill effluent was found to be 0.5% accompanied by more than 2-fold increase in the output of the treatment.

It is thus found that the waste liquors containing dissolved iron and aluminum have excellent scope in the treatment of high COD effluents. If these liquors are used in the mixed form, the efficacy of the treatment is further improved, in addition to the increase in the output in terms of the treatable volumes of the respective high COD effluents.
SUMMARY

This chapter is devoted to the interactability studies of those cases where three effluents originating from different sources combined together, and interacted with each other in a manner that the acidity and alkalinity of the component effluents were eliminated altogether, and the pollutant species present in the effluents were separated as insoluble products and which in-turn removed other pollutant species of soluble nature through the process of surface adsorption. The net output of the ternary interactions was found to be in the form of resultant mixtures whose physico-chemical characteristics were found to be wholly or substantially improved.

The intractability studies were planned in a manner such that one component out of three in each mixture was the galvanizing plant effluent. Taking into account the key role of this effluent, the genesis and the data with regard to its quantum of discharge were evaluated to ensure the availability of this effluent. The other two effluents taken here were both of alkaline nature. The component-members of the ternary mixtures were as follows: (i) Textile mill effluent (pH 10.64) + Rice mill effluent (pH 5.14) + Galvanizing effluent (pH 2.30) (ii) Soap plant effluent (pH 11.64) + Distillery effluent (pH 4.40) + Galvanizing plant effluent (pH 2.30) (iii) Soap plant effluent (pH 11.64) + Phosphatic fertilizer plant effluent (pH 1.40) + Galvanizing plant Effluent. (iv) Textile mill effluent (pH 10.64) + Distillery effluent (pH 4.40) + galvanizing plant effluent (pH 2.3). Two sets of each ternary mixture were prepared. These sets were prepared to produce equilibrium pH of 7.00 and 5.50 of the respective mixtures. In the first step, the physico chemical characteristic (pH, TDS, Conductance, ORP, COD, Ca-hardness, Mg-hardness, chloride, sulphate, and dissolved
iron) of the galvanizing plant effluent and the five other effluents of alkaline nature used here were determined by standard procedures.

In the second step, four binary mixtures were prepared as follows: (i) Textile mill effluent + Rice mill effluent, giving an equilibrium of pH 7.75 (ii) Soap plant effluent + Distillery effluent, giving an equilibrium of pH 7.86 (iii) Soap plant effluent + Phosphatic fertilizer plant effluent, giving an equilibrium pH 8.55 (iv) Textile mill effluent + Distillery effluent, giving an equilibrium of pH 8.22. The ratios (v/v) in which the components were mixed were recorded.

In the third step, each binary mixture was made to interact with galvanizing plant effluent producing an equilibrium pH 7.00 of the mixture. Parallels runs producing equilibrium pH 5.50 of the resulting mixtures were also prepared. In the last and final step, the physico-chemical characteristics of each mixture were determined by standard procedures. The results showed that the COD removal in the ternary mixtures was in the range 67.0%-96.9%. The TDS removal was in the range 38.3%-94.0%. The removal of the ionic species (Ca$^{2+}$, Mg$^{2+}$, Cl$^-$, SO$_4^{2-}$) was up to extents ranging from 20% to 100%. The removal of TDS and COD values at the equilibrium pH 7.00 was found to be marginally higher in all the cases, compared to those at pH 5.50. The removal of the organic species was, however, found to be higher at pH 5.50. The dissolved iron indicated a higher presence at pH 5.50. The excessive alkalinities associated with the soap plant and textile mill effluent, and the excessive acidities associated with the galvanizing and phosphatic fertilizer plant effluent were all found eliminated.
In the second part of the studies, the selected effluents of alkaline nature were made to interact with a mixture (1:1, v/v) of galvanizing liquor and alum plant liquor. Studies were carried out in steps as follows: (i) The selected effluents from soap plant, textile mill, copper ore-concentrate plant and milk processing plant were each made to interact separately with the galvanizing liquor and alum plant liquor producing an equilibrium pH 7.00 in each case. The percent removal of COD was determined in each reactions mixture. (ii) The mixture (1:1, v/v) of the galvanizing plant liquor and alum plant effluents was first prepared. The alkaline effluents were then separately made to interact with the mixture of the liquors producing an equilibrium pH 7.00 in each mixture.

The result showed that the highest synergistic gain (18.2%) was obtained when the dissolved iron and aluminium interacted combinely with the copper ore-concentrate effluent. The COD removal in the combined case was found to be 96.2%, compared to 56.0% and 93.2% when this effluent was treated separately with the galvanizing liquor and alum liquor respectively. 1 mL each of the galvanizing liquor and the alum liquor was found to interact effectively with 71.4 mL and 250.0 mL of the copper ore-concentrate effluents respectively. The same volume (1mL + 1mL) of the respective liquors in the form of their mixture was found to interact effectively with as much as 666.6 mL of the same copper ore concentrate effluent. The combination of the two liquors have thus provided a higher output of the treated effluent, in addition to a higher removal of COD. The synergistic gains with other effluents were found as follows: Soap Plant effluent-15.7%, milk processing plant effluent-3.6%, textile mill effluent-0.5%. The output of the treatment was found to be significantly enhanced in each case.
It was concluded that when these liquors were used in the mixed form, the efficacy of the treatment was enhanced, producing at the same time enhanced output in terms of the treatable volumes of the respective high COD effluents.
REFERENCES


