CHAPTER III

SECTION - A

KIDNEY
PHYSICOCHEMICAL CHARACTERISTICS OF RUNOFF WATERS:

The samples of fresh iron ore rejects were subjected to 10 cm of rain by means of rain simulator. The runoff collected was then used for heavy metal detections and for hydrological studies. The heavy metals in the runoff are compiled in Table 'A' and the physicochemical characteristics of water are given in Table 'B'.

The runoff showed the presence of Barium, Cadmium Cobalt, Chromium, Copper, Iron, Magnesium, Manganese, Nickel, Lead, Strontium, and Zinc in various concentrations. Iron concentration (1910.5 ± 4.2 μg/I) was found to be the highest of all, followed by manganese (857.0 ± 1.37 μg/I); cadmium (710.0 μg/I) and barium (650.0 ± 1.0 μg/I). The concentrations of chromium, cobalt, copper, magnesium, nickel, lead, strontium, and zinc were equivalent to 28.8 ± 0.59, 37.0 ± 0.38, 14.6 ± 1.0, 214.0 ± 2.8, 11.9 ± 0.89, 5.4 ± 0.5, 11.3 ± 0.71 and 81.4 ± 1.0 μg/I respectively.

Oxygen and carbon dioxide concentration of mining runoffs was equivalent to 15.8 ± 1.02 and 7.3 ± 0.28 mg/I respectively. The phenolphthalein acidity, total alkalinity, inorganic phosphorus, total phosphorus, organic phosphorus and sulphate concentrations of runoffs was equivalent to 9.70 ± 0.57, 14.0 ± 1.01, 3.073 ± 0.37, 23.217 ± 1.28, 20.144 ± 1.72 and 146.15 ± 3.0 mg/I respectively.

The mining effluents also showed the presence of total solids, total dissolved solids, nitrates and hardness, equivalent to 1.91 ± 0.01, 0.089 ± 0.001, 1.371 ± 0.13 and 8.713 ± 0.27 gm/l respectively. The runoff was acidic (pH 6.1) and the specific conductance and redox potentials were equivalent to 51.0 ± 3.0 μMho and 0.2176 ± 0.001 volts respectively.
<table>
<thead>
<tr>
<th></th>
<th>Metal</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ba</td>
<td>650.0 ± 1.0 μg/L</td>
</tr>
<tr>
<td>2.</td>
<td>Cd</td>
<td>710.0 ± 2.0 μg/L</td>
</tr>
<tr>
<td>3.</td>
<td>Co</td>
<td>22.80 ± 0.59 μg/L</td>
</tr>
<tr>
<td>4.</td>
<td>Cr</td>
<td>37.0 ± 0.38 μg/L</td>
</tr>
<tr>
<td>5.</td>
<td>Cu</td>
<td>14.6 ± 1.0 μg/L</td>
</tr>
<tr>
<td>6.</td>
<td>Fe</td>
<td>1910.5 ± 4.20 μg/L</td>
</tr>
<tr>
<td>7.</td>
<td>Mg</td>
<td>214.0 ± 2.80 μg/L</td>
</tr>
<tr>
<td>8.</td>
<td>Mn</td>
<td>857.0 ± 1.37 μg/L</td>
</tr>
<tr>
<td>9.</td>
<td>Ni</td>
<td>11.90 ± 0.89 μg/L</td>
</tr>
<tr>
<td>10.</td>
<td>Pb</td>
<td>5.40 ± 0.50 μg/L</td>
</tr>
<tr>
<td>11.</td>
<td>Sr</td>
<td>11.30 ± 0.71 μg/L</td>
</tr>
<tr>
<td>12.</td>
<td>Zn</td>
<td>81.40 ± 1.0 μg/L</td>
</tr>
</tbody>
</table>
TABLE B : PHYSICOCHEMICAL CHARACTERISTIC OF RUNOFF WATER:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carbon dioxide (mg/L)</td>
<td>7.30 ± 0.28</td>
</tr>
<tr>
<td>2.</td>
<td>Dissolved Oxygen (mg/L)</td>
<td>15.80 ± 1.02</td>
</tr>
<tr>
<td>3.</td>
<td>Phenolphthalein acidity (mg/L)</td>
<td>9.70 ± 0.57</td>
</tr>
<tr>
<td>4.</td>
<td>Total alkalinity (mg/L)</td>
<td>14.0 ± 1.01</td>
</tr>
<tr>
<td>5.</td>
<td>Inorganic phosphorus (mg/L)</td>
<td>3.07 ± 0.37</td>
</tr>
<tr>
<td>6.</td>
<td>Total phosphorus (mg/L)</td>
<td>23.217 ± 1.28</td>
</tr>
<tr>
<td>7.</td>
<td>Organic phosphorus (mg/L)</td>
<td>20.144 ± 1.72</td>
</tr>
<tr>
<td>8.</td>
<td>Sulphate (mg/L)</td>
<td>146.15 ± 3.0</td>
</tr>
<tr>
<td>9.</td>
<td>Total solids (gm/L)</td>
<td>1.91 ± 0.01</td>
</tr>
<tr>
<td>10.</td>
<td>Total dissolved solids (gm/L)</td>
<td>0.089 ± 0.001</td>
</tr>
<tr>
<td>11.</td>
<td>Nitrate (gm/L)</td>
<td>1.371 ± 0.13</td>
</tr>
<tr>
<td>12.</td>
<td>Hardness (gm/L)</td>
<td>8.713 ± 0.27</td>
</tr>
<tr>
<td>13.</td>
<td>Specific conductance (µMho)</td>
<td>51.0 ± 3.0</td>
</tr>
<tr>
<td>14.</td>
<td>Redox potential (volts)</td>
<td>0.217 ± 0.001</td>
</tr>
<tr>
<td>15.</td>
<td>pH</td>
<td>6.10 ± 0.01</td>
</tr>
</tbody>
</table>
I] HISTOLOGY OF THE BIRD KIDNEY:

In order to facilitate better understanding of the morphological changes induced by mining effluents in the kidney, it is felt desirable to give a brief account of the normal histology of the bird kidney before mentioning the morphological changes appearing in the kidney after the exposure to the mining effluents. The histological features of the duck kidney are as follows:

a] Gross morphology:

The kidneys of birds are paired structures lying in pelvic skeletal depression along the backbone. They comprise about 1% of the body weight being somewhat larger in small birds (Johnson, 1968); and in species having functional salt glands (Hughes, 1970). Each kidney is usually composed of three lobes (cranial, middle and caudal), although this location is more or less distinct and the relative size of the lobes varies considerably among species (Johnson, 1968). The ureter lies along the ventral surface of the kidney and receives major branches from each lobe. Major circulatory connections have been studied. The arterial blood supply is from the renal artery which supplies the cranial lobe, and the branches of the sciatic artery to the middle and caudal lobe (Siller and Hindle, 1969). The femoral artery may also branch to the kidney (Sturkie, 1965). Avian kidney receives venous blood from the legs, tail and mesenteries via the renal portal system and renal veins provide for the drainage to the vena cava.

b] Nephrons:

The kidney of the normal bird comprises numerous functional excretory units termed as nephrons. Birds possess two basic types of nephrons, including cortical nephrons composed of glomerulus, proximal and distal
convoluted tubules and less numerous juxta medullary or looped nephrons in which the proximal and distal tubules are separated by a loop of Henle which extends into the medulla.

The glomeruli are small and contain few capillary loops. The cells of the proximal tubules have a brush border to the luminal surface (Sperber, 1960), similar to those of mammals and vertebrates in general.

The basal (capillary facing) surfaces of these cells exhibit numerous small projections similar to those reported for gecko (Roberts and Schmidt-Nielson, 1966) rather than the extensive folding into the mitochondria containing compartments typical of mammals.

The cells of the avian distal tubule also differ from those of the mammals in that they have selectively flat basal membranes (Sperber, 1960; Poulson, 1968). Henle's loop in bird also differs in several respects from that of mammals. There are no abrupt transitions between thin and thick segments. Instead, the proximal tubule generally narrows, loses its brush border and continues into the medulla with no change in staining properties (Poulson, 1968). The cells of the thin limb of bird are higher than the squamous epithelium of the mammalian thin limb (Sperber, 1960). As in the short looped nephrons of mammals, the turn of the loop occurs in the ascending (thick) limb. The thick limb resembles that of mammals in that, the cells are characterized by striations due to parallel mitochondria (Sperber, 1960) and the general association of this cell type with active Na⁺ transport is consistent with the probable role of the thick limb as counter current multiplier system.

The nephrons of birds like those of mammals have a region of attachment of the afferent glomerular arteriole and a loop of the distal convoluted tubule at Bowman's capsule. Cells in the arteriole called "Juxta glomerular cells" exhibit characteristic granules thought to contain renin. The adjacent cells of the distal convoluted tubule possess large prominent nuclei
and form the "Macula densa". Juxtaglomerular cells and macula densa together form the juxta glomerular apparatus (Taylor et al., 1970).

Each nephron consists of a renal capsule, a coiled uriniferous tubule and interstitial haematopoietic tissue. The renal capsule is made up of a glomerulus and Bowman's capsule. Glomerulus is a network of blood capillaries connecting afferent arterioles with efferent arterioles. Glomerular walls are very thin and consists principally of squamoid endothelial cells.

The Bowman's capsule is cupshaped, double-walled structure of which the inner one closely surrounds the glomerulus. This inner wall is composed of visceral epithelium and closely adheres to the capillaries of the glomerulus. The cells of the visceral epithelium are squamoid in nature. The outer wall is known as parietal layer. The latter is thicker than the inner-wall as it is formed mainly of cuboidal cells. A space termed as Bowman's space separates the inner wall from the outer one.

Bowman's capsule is actually the proximal terminal end of the uriniferous tubule and is followed by a tubular neck. Other regions of the tubule are a proximal tubule and a distal tubule. The cells of the collecting tubules are cuboidal and possess centrally placed nuclei. The brush border is absent. Apical mucous granules are prominent in these cells. The proximal tubules bear thin microprocesses called microvilli at the luminal side which form the brush border. The distal tubules do not possess the brush border and their lumen is wide.

The duck kidney contains two types of nephrons: those with no loops of Henle, they are of reptilian type and are located exclusively in the cortex and those of the mammalian type, with long or intermediate length loops, located in the medulla (Braun and Dantzler, 1972).
III] HISTOPATHOLOGICAL ALTERATIONS:

General:

The routine haematoxylin - eosin staining techniques employed to the kidney sections of the ducks exposed to various concentrations of mining effluents (M.E.) for different time intervals revealed histopathological changes in the renal capsule (Glomeruli + Bowman's capsule), proximal tubules, distal tubules and collecting tubules. The histopathological changes occurring in the kidney showed concentration dependency and time dependency, especially the higher concentrations of mining effluents had profound influence on the kidney which showed progressive damage as the time passed. Similarly, the lower concentrations did exhibit time dependent progress in the renal alterations up to certain extent. When the ducks were sacrificed for various time intervals, between thirty minutes of exposure to M.E. and five hours of M.E. exposure no detectable damage to the kidneys was observed, only in a few cases the early necrotic changes like slight swelling of glomeruli, marginal increase in the lumen diameter of the tubules, occasional marginal swelling of the tubule cells were seen but the end of six hours onwards, the renal form changes were detectable and also were quite significant and these changes were not only dose dependent but also progressive.

ALTERATIONS IN THE RENAL CAPSULE:

For the sake of convenience the changes in the renal capsule are clubbed together under glomeruli and described as glomerular changes.

GLomeruli:

The glomerular changes in general were beginning with the swelling of the glomeruli and then progressing towards distortion which included disruption
of glomerular walls, vacuolisation or development of empty spaces, release of
glomerular exudents into the Bowman's space, breakage of capillaries leading
to the bleeding and escape of blood cells. The changes in Bowman's capsule
were like, widening of Bowman's space, disruption of Bowman's walls - both
inner and outer, change in the shape of Bowman's capsule caused either by
acute swelling or shrinkage and sometimes the breakage of glomerulus as well
as Bowman's capsule was observed. The intensity of the necrotic changes
depended upon the concentration and the duration of exposure to the mining
effluents. The number of renal capsules getting affected depended upon the
concentration of the mining effluents.

The ducks exposed to 0.01% M.E. did not show any significant change
in the renal capsule up to the end of twenty nine days but showed slight
swelling of glomeruli. At the end of seven hundred and twenty hours about
10% glomeruli showed necrotic glomeruli. The main features of glomerular
damage were change in shape of the glomeruli, widening of Bowman's space,
vacuolisation of the glomeruli and in a few cases, slight widening of Bowman's
space (Plate 1; Fig.2).

The 0.01% concentration of M.E. induced change in the shape and slight
vacuolisation of the glomeruli (Plate 1: Fig 3) at the end of one thousand and
eighty hours. About 15% corticlar glomeruli exhibited damage.

The 0.1% M.E. induced necrosis of about 15% glomeruli at the end of six
hours and the exudents were seen in the Bowman's space (Plate 1. Fig 4).
Then, up to twenty four hours there was neither further damage to the glomeruli
nor there was increase in the number of affected glomeruli. But at the end of
twenty four hours there was increase in the severity of the damage. The
glomeruli showed the change in shape, vacuolisation, disruption of Bowman's
wall, widening of Bowman's space and exudents were seen in the Bowman's
space (Plate 2 : Fig 2). About 18 percent glomeruli were affected. At the end
CAPTIONS TO THE FIGURES

PLATE 2 :

Fig. 1 : 0.1% M. E. - 12 hours. (20 x 5)
Note the RBCs (R) in the interstitium of the damaged tubules, vacuolisation of the proximal tubule (PT), distortion and vacuolisation (V) of the distal tubule (DT).

Fig 2 : 0.1% M. E. - 24 hours. (40 x 5)
Note the change in the shape of the glomerulus (G), disruption of Bowman's wall (arrow), widening of Bowman's space, vacuolisation (V) of the distal tubules (DT) with disruption of the luminal border, disruption of proximal tubule (PT) with the loss of basal membrane and vacuolisation (V).

Fig 3 : 0.1% M. E. - 48 hours. (20 x 5)
Note the damaged distal tubule (DT) with vacuolisation (V) and disruption of the basal membrane, damaged proximal tubule (PT), collecting tubules (CT) with exudents (E) in the lumen.

Fig 4 : 0.1% M. E. - 72 hours. (20 x 5)
Note the damaged glomerulus (G) distortion of the tubule (arrow) and RBCs on the distorted tubules.
CAPTIONS TO THE FIGURES

PLATE 3 :

Fig. 1 : 0.1% M. E. - 120 hours. ( 10 x 5 )
Note the broken glomerulus (G) with widening of Bowman’s space (arrow), distorted proximal tubule (PT).

Fig. 2 : 1.0% M. E. - 6 hours. ( 10 x 5 )
Note the damaged proximal and distal tubules (PT, DT), and the collecting tubules with the debris (D) in the lumen.

Fig. 3 : 1.0% M. E. - 12 hours. ( 20 x 5 )
Note the damaged collecting tubules (CT) with disruption of the luminal border, damaged glomerulus (G) with exudents in Bowman's space, damaged distal tubule (DT) and vacuolisation (arrow) of the proximal tubule.

Fig. 4 : 1.0% M. E. - 24 hours. ( 20 x 5 )
Note the damaged collecting tubule (CT) with broken luminal border (double arrow), distorted distal tubule with a debris (D) in the lumen. Also note the damaged luminal border (arrow) of distal tubule (D.T.).
PLATE NO 4

Diagram with labeled areas:
- D
- PT
- G
- DT
- CT
- PT
- R
CAPTIONS TO THE FIGURES

PLATE 4:

Fig 1: 1.0% M. E. - 48 hours. (20 x 5)
Note the RBCs (R) in the interstitial spaces, loss of basal membrane (arrow) of the proximal tubule, damaged glomerulus (G) with exudents (double arrow) in Bowman's space, damaged proximal and distal tubules (PT, DT) and collecting tubules (CT) with the loss of luminal border.

Fig 2: 1.0% M. E. - 72 hours. (20 x 5)
Note the damaged collecting tubules (CT), distorted distal tubules (arrow) and damaged proximal tubule (PT).

Fig 3: 1.0% M. E. - 96 hours. (20 x 5)
Note the damaged glomerulus (G) with empty spaces and exudents (arrow) in Bowman's space, damaged distal tubule (DT) and disrupted proximal tubule (PT).

Fig 4: 1.0% M. E. - 120 hours. (20 x 5)
Note the RBCs (R) in the interstitial spaces, swollen glomerulus (G) with the loss of Bowman's space.
CAPTIONS TO THE FIGURES

PLATE 5 :

Fig 1 : 5.0% M. E. - 6 hours. (20 x 5)
Note the damaged glomerulus (G) with exudents (double arrow) in Bowman's space, the damaged distal tubule (DT) with the loss of luminal border (arrow), damaged proximal tubule (PT) with vacuolisation and disruption of brush border (arrow).

Fig 2 : 5.0% M. E. - 12 hours. (20 x 5)
Note the broken glomerulus (G) with vacuolisation (arrow) and widening of Bowman's space.

Fig 3 : 5.0% M. E. - 24 hours. (20 x 5)
Note the damaged glomerulus with exudents (double arrow) in Bowman's space, damaged distal tubule (DT) and also note the development of empty spaces (arrow) in between the cells of the proximal tubule (PT).

Fig 4 : 5.0% M. E. - 48 hours. (20 x 5)
Note the damaged glomerulus (G) with exudents in Bowman's space, vacuolisation (V) of the tubules and widening of interstitium (arrow) containing exudents.
the end of twentyfour and fortyeight hours the glomeruli showed some vacuolisation, widening of Bowman's space with or without exudents (Plate 5: Figs 3 and 4). There was no further increase in the number of necrotic glomeruli at these hours. At the end of seventytwo hours, some glomeruli were acutely necrotic and exhibited: change in shape, disruption of the glomerular structure and presence of exudents in Bowman's space (Plate 6: Fig 1). By the end of ninetysix and one twenty hours the glomeruli exhibited: disruption, vacuolisation and exudents in Bowman's space and in few cases damage to the Bowman's wall was seen (Plate 6: Figs 2 and 3). By the end of both ninetysix and one twenty hours, thirtysix percent glomeruli were necrotic.

The 10.0% M.E. induced damage to about thirty six percent glomeruli at the end of six hours. The glomeruli appeared to be distorted and showed exudents in Bowman's space. In a few cases, the outer wall of Bowman's capsule was disrupted or eroded (Plate 6: Fig 4). At the end of twelve hours a few glomeruli showed loss of its connection to the afferent and efferent glomerular arterioles (Plate 7: Fig 1) and in few cases, the connection was intact with exudents extending from its sides to the Bowman's space. By the end of fortyeight hours the disruption of the Bowman's wall was seen and the glomeruli in the process of losing its connection with glomerular arterioles were seen and such glomeruli showed the cleft to its side (Plate 7: Fig 3). There was no increase in the number of necrotic glomeruli at this time interval.

By the end of seventy two hours the glomeruli were acutely damaged with pronounced vacuolisation. The Bowman's inner wall was disrupted and erosion of outer wall was also seen in few instances. Along with the glomerulus the juxta glomerular apparatus was also damaged (Plate 7: Fig 4). The exudents were seen in Bowman's space.

At the end of ninetysix and seventy two hours about 40% of the glomeruli were necrotic. The change in the shape of glomeruli and distortion of glomerular tuft was seen. The disruption of the Bowman's inner and outer wall
CAPTIONS TO THE FIGURES

PLATE 7:

Fig 1 : 10.0% M. E. - 12 hours. ( 20 x 5 )
Note the swollen glomeruli (G) and acutely damaged tubules (arrow)

Fig 2 : 10.0% M. E. - 24 hours. ( 20 x 5 )
Note the acutely damaged distal tubule (DT) with debris (-D-) in the lumen, acutely damaged collecting tubules (CT) with disruption of luminal border and accumulation of debris (D) in the lumen.

Fig 3 : 10.0% M. E. - 48 hours. ( 20 x 5 )
Note the swollen and damaged glomerulus (G) with disruption of Bowman's wall (arrow), damaged proximal tubule (PT) and distorted distal tubule (DT) with the debris (D) in the lumen.

Fig 4 : 10.0% M. E. - 72 hours. ( 20 x 5 )
Note acutely damaged glomerulus (G) with exudents in Bowman's space (arrow) acutely vacuolised distal tubule (DT) and distorted collecting tubules (CT) with debris (D) in the lumen.
CAPTIONS TO THE FIGURES

PLATE 6:

Fig 1: 5.0% M. E. - 72 hours. (20 x 5)
Note the damaged glomerulus (G) with exudents in Bowman’s space, damaged distal tubule (DT) with vacuolisation (double arrow), damaged proximal tubule (PT) with the debris (arrow) in the lumen.

Fig 2: 5.0% M. E. - 96 hours. (20 x 5)
Note the damaged glomerulus (G) with exudents in Bowman’s space, damaged proximal and distal tubules (PT, DT) with debris (arrow) in the lumen.

Fig 3: 5.0% M. E. - 120 hours. (20 x 5)
Note the damaged glomerulus (G) with empty spaces, extreme vacuolisation (V) of the proximal and distal tubules leading to the loss of integrity.

Fig 4: 10% M. E. - 6 hours. (20 x 5)
Note the distorted glomeruli (G) and exudents (arrow) in Bowman’s space, vacuolised distal and proximal tubules (DT, PT).
CAPTIONS TO THE FIGURES

PLATE 9:

Fig 1: 50.0% M. E. - 24 hours. (20 x 5)
Note the necrotic glomerulus (G) with exudents in the Bowman's space, distorted proximal and distal tubules (PT, DT).

Fig 2: 50.0% M. E. - 48 hours. (20 x 5)
Note the glomerulus (G) with acute vacuolisation (arrow), displacement of the tubule cells nuclei (N) and the pycnotic nuclei (NP). Also note the loss of integrity of tubules.

Fig 3: 50.0% M. E. - 72 hours. (20 x 5)
Note swelling of glomerulus (G) and filling of Bowman's space by exudents, acute vacuolisation of tubules (CT), loss of tubule integrity and disruption of tubular lumina.

Fig 4: 50.0% M. E. - 96 hours. (20 x 5)
Note the damaged collecting tubules (CT), damaged proximal tubules with pycnotic nuclei (NP), the accumulation of cytoplasmic debris (D) in the lumen.
CAPTIONS TO THE FIGURES

PLATE 8:

Fig 1: 10.0% M. E. - 96 hours. (20 x 5)
Note the swollen and distorted glomeruli (G) with exudents (arrow) in Bowman's space, acutely distorted distal tubule (DT) with the loss of luminal border.

Fig 2: 10.0% M. E. - 120 hours. (20 x 5)
Note the acutely damaged tubules with acute vacuolisations (arrow).

Fig 3: 50.0% M. E. - 6 hours. (20 x 5)
Note widening of Bowman's space (arrow) with exudent, distortion of tubules with vacuolisation (V) also note the disruption of lumen border (DT - arrow).

Fig 4: 50.0% M. E. - 12 hours. (20 x 5)
Note the distorted glomerulus (G) with exudents (arrow) in the Bowman's space, acute distortion of distal tubule with loss of basal membrane (arrow) the nuclear exudents (E) and RBCs (R) in the interstitium.
of seventy two hours the glomerular damage was seen but there was no increase in the number of affected glomeruli (Plate 2 : Fig 4).

By the end of one twenty hours about twenty percent of glomeruli were found damaged and the main feature was the shrinkage of glomeruli with widening of Bowman’s space (Plate 3 : Fig1).

The glomeruli under the influence of 1.0% M.E. showed reduction in size, presence of exudents in the Bowman’s space and vacuolisation (Plate 3 : Fig3). About 20% glomeruli exhibited damage, while about 2-3 percent showed the early necrotic changes such as swelling, slight change of shape and changes in Bowman’s space. These changes with glomerular necrosis described above were seen at the end of six, twelve, twenty four and fortyeight hours, especially at the end of fortyeight hours the percentage of the affected glomeruli did not increase, but exudents were seen in the Bowman’s space and these exudents sometimes filled the major portions of the Bowman’s space (Plate 4 : Fig 1). At the end of ninetysix and one twenty hours, the changes in the shape of the glomeruli, glomerular swelling, vacuolisation and casting of exudents were observed (Plate 4 : Fig 3 and 4). In a few cases, the disruption of Bowman’s wall was observed. About twentyeight percent glomeruli were found damaged at the end of ninetysix and one twenty hours.

The 5.0% M.E. induced damage to about twentyeight to thirty percent renal capsules (glomeruli + Bowman’s capsule) at the end of six hours. There was no increase in the number of necrotic glomeruli up to the end of forty eight hours. At the end of six hours a few glomeruli showed change in shape, widening of Bowman's space while others showed swelling with large empty spaces in the glomeruli, disruption of the walls of Bowman's capsule and casting of exudents in the Bowman's space (Plate 5 : Fig 1).

At the end of twelve hours some glomeruli exhibited shrinkage leading to change in shape and significant widening of Bowman's space (Plate 5 : Fig 2). Besides this, the cleaving of glomerulus was also observed in a few cases. By
was seen in some cases. Many glomeruli showed the casting of exudents into Bowman's space. The juxta glomerular apparatus appeared to be damaged (Plate 8: Fig 1).

The 50% M.E. promoted damage to 45% of the glomeruli at the end of six hours. A few glomeruli with extreme widening of Bowman's space were seen. (Plate 8: Fig 3). By the end of twelve hours, the glomeruli were distorted with disruption of Bowman's walls and showed exudents in the Bowman's space (Plate 8: Fig 4).

At the end of twenty-four hours the glomeruli were necrotic and the exudents in the form of nuclei and blood cells were found in the Bowman's space (Plate 9: Fig 1). There was no further change in the number of affected glomeruli at this time interval, in comparison to that seen at the end of six hours. At the end of forty-eight hours, few glomeruli showed a large empty space in them (Plate 9: Fig 2) with the disruption of Bowman's inner wall and release of exudents in the Bowman's space. By the end of seventy-two hours, few glomeruli showed acute swelling and filling of Bowman's space with exudents (Plate 9: Fig 3). The disruption of Bowman's wall was also seen. Besides, there was 2% increase in the number of necrotic glomeruli at this time interval.

By the end of the one twenty hours there was 6% increase in the number of necrotic glomeruli. There was significant increase in the Bowman's space and the glomerular shape appeared to be changed. The Bowman's space showed the presence of exudents (Plate 10: Fig 1).

The exposure to 100% M.E. induced necrosis in about sixty percent glomeruli at the end of six hours. The glomeruli showed acute swelling with blood cells, vacuolisation, release of exudents in Bowman's space and also the macula densa appeared to be damaged (Plate 10: Fig 2) and the necrosis of glomeruli did not progress much up to the end of twenty-four hours, where the glomerular contents invaded the Bowman's space (Plate 10: Fig 4).
The kidney exhibited presence of about seventy percent necrotic glomeruli at the end of one twenty hours where the macula densa also showed necrosis. The Bowman's space showed the presence of exudents (Plate 11: Fig.4).

THE ALTERATIONS IN PROXIMAL AND DISTAL TUBULES:

The alterations in the proximal and distal tubules were similar when the ducks were exposed to different concentrations of M.E. for various time intervals. Hence, these are described together. For all the concentrations of M.E., there were in-significant changes in the proximal and distal tubules before six hours. Only a very few tubules exhibited slight swelling in one of the tubule cells or sometimes a marginal increase in the size of the tubule indicating swelling. The control animals' kidneys showed normal proximal and distal tubules. The ducks exposed to 0.1, 1.0, 5.0, 10.0, 50.0 and 100.0 percent mining effluents exhibited necrosis in about 15%, 20%, 28-30%, 36%, 45% and 60% proximal and distal tubules at the end of six hours. The necrosis was progressive and involved more tubules as the time progressed. The birds exposed to 0.01% M.E. did not show any change in the proximal and distal tubules up to the end of twenty nine days. At the end of seven hundred and twenty and one thousand and eighty hours, the 10% and 15% tubules respectively were found necrotic.

Both the proximal and distal tubules showed necrotic changes, such as swelling of cells, disruption of tubules, vacuolisation of tubule cells, loss of brush border in proximal tubules and disruption of luminal borders, loss of basal membranes, pycnosis of tubule nuclei, exudation of cytoplasm and nuclei into the interstitium in the bird exposed to 0.01% M.E. for seven twenty and one thousand and eighty hours (Plate 1 : Fig 2 and 3).

The ducks exposed to 0.1 to 100% M.E. exhibited pronounced necrosis of both the proximal and distal tubules and most of the necrotic changes
mentioned above for 0.01% M.E. exposure, were seen but in addition the changes such as sloughing off of cells into the lumen to form the cellular debris, the widening of interstitium, the occurrence of blood cells in the interstitium, acute vacuolisation marked with loss of tubular architecture was observed (Plate 1: Figs 2, 3 and 4; Plate 2: Figs, 1, 2, 3 and 4; Plate 3: Figs 1, 2, 3 and 4; Plate 6: Figs 1, 2, 3 and 4; Plate 7: Figs 1, 2, 3 and 4; Plate 8: Figs, 1, 2, 3 and 4; Plate 9: Figs 1, 2, 3 and 4; Plate 10: Figs 1, 2 and 3; and Plate 11: Figs 1, 2, 3 and 4).

The 0.1% M.E. induced a slight increase in the number of necrotic tubules at the end of twenty four hours and about eighteen percent tubules were necrotic. All the concentrations (except 0.1%) of mining effluents did not increase the number of necrotic tubules from twelve to ninety six hours. By the end of one twenty hours, twenty, twenty eight, thirty six, forty, fiftysix and seventy percent of proximal and distal tubules were necrotic under the influence of 0.1, 1.0, 5.0, 10.0, 50.0 and 100.0 percent mining effluents respectively.

ALTERATION IN THE COLLECTING TUBULES:

Under the influence of 0.1, 1.0, 5.0, 10.0, 50.0 and 100.0 percent M.E. fifteen, twenty, thirty, thirtyfive to forty, fifty and sixty to sixtyfive percent of collecting tubules showed necrosis by the end of six hours. Only the 0.01% M.E. did not induce any necrosis in the collecting tubules up to the end of twentynine days. By the end of seven twenty and one thousand eighty hours, about 10 and 15 percent tubules showed necrotic changes. The collecting tubules did not show numerical rise in necrosis upto one twenty hours under the influence of mining effluents. But at the end of one twenty hours, 0.1, 1.0, 5.0, 10.0, 50.0 and 100.0 percent M.E. induced necrosis to twenty, thirty, thirtyfive, fortytwo, fiftyfive and seventy percent collecting tubules.
CAPTIONS TO THE FIGURES

PLATE 10 :

Fig 1 : 50.0% M. E. - 120 hours. ( 20 x 5 )
Note the damaged glomeruli (G) with exudents (arrow) in the Bowman's space, the damaged tubules (double arrow)

Fig 2 : 100.0% M. E. - 6 hours. ( 20 x 5 )
Note the swelling of glomerulus (G) with exudents (arrow) in Bowman's space, vacuolisation (V) of the tubules and accumulation of debris (D) in the lumen.

Fig 3 : 100.0% M. E. - 12 hours. ( 20 x 5 )
Note the damaged tubules (CT), acute vacuolisation (V) and accumulation of debris (D) in the lumen.

Fig 4 : 100.0% M. E. - 24 hours. ( 20 x 5 )
Note the damaged collecting tubules (CT), swollen glomerulus (G) with exudents (arrow) in Bowman's space, accumulation of debris (D) in the lumen of distal tubule, pycnotic nuclei (NP).
CAPTIONS TO THE FIGURES

PLATE 11:

Fig 1: 100.0% M. E. - 48 hours. (20 x 5)
Note the distorted collecting tubules (CT), proximal tubules (PT) filled with derbis (D) in the lumen, distal tubule (DT) with disrupted luminal border, pycnotic nuclei (NP) in the tubule cells.

Fig 2: 100% M. E. - 72 hours. (20 x 5)
Note the damaged collecting tubules (CT), distorted proximal tubule (PT) and distal tubule (DT).

Fig 3: 100.0% M. E. - 96 hours. (20 x 5)
Note acutely damaged distal tubule (DT) and proximal tubule (PT), debris (D) in the lumen.

Fig 4: 100.0% M. E. - 120 hours. (20 x 5)
Note acutely damaged collecting tubules, distorted glomerulus (G), damaged proximal tubule (PT), vacuolisation (V) in the collecting tubule.
II] NORMAL AND ULTRA STRUCTURAL CHANGES IN KIDNEY:

The functional unit of kidney is a nephron, which includes glomerulus and the tubules. The normal glomerulus (Plate 12 : Fig 1) is a vascular epithelial organ with tufts of capillaries arranged in the form of lobules and a supporting framework of extracellular matrix and cells in so-called centrilobular location called the Mesangium. The capillary walls of glomerulus consist of three layers: endothelium, basement membrane and epithelium (podocyte). Foot processes are also present which are separate and are not fused. The clusters of capillaries are freely suspended within the Bowman's capsule from the point of its attachment at the vascular pole. Thus, it has two functional spaces, the capillary lumina and the Bowman's space/cavity or urinary space.

The tubules of the kidney are mainly of three types: Proximal, Distal and Collecting. The proximal tubule (Plate 12 : Fig 2) is a heterogeneous structure with tall epithelium and the apical membrane is greatly expanded in the form of closely packed microvilli as brush border. The lumen of the proximal tubule is narrow without tissue debris. Normal proximal tubule showed intact mitochondria, intact lysosomal vesicles, no cytoplasmic vacuolisation and no deposition of heavy metal in the cytoplasm and nucleus (Plate 12 : Fig 2).

Distal tubules of the kidney of ducks, show normal nucleus with no deposition of heavy metals, intact chromatin material in the nucleus, no deposition of lipid droplets in cytoplasm, wide luminal space with intact luminal border and intact mitochondria in the tubule cells (Plate 12 : Fig 3).

The collecting tubules of the kidney are slightly larger in size with tubule cells more in number than the distal tubules. The nucleus is spherical and located more towards the luminal border. The luminal border and tubule basement membrane is intact with intact mitochondria and no lipid droplets in
CAPTIONS TO FIGURES

PLATE 12:

Fig 1 : Normal glomerulus (1 x 8000)
Note normal mesangial area (M.E.), podocyte (P) foot processes (F), basement membrane (B.M) and Bowman's space (U). capillary lumen (Cp.L), endothelium (En).

Fig 2 : Control Proximal tubules (1 x 5,000)
Note intact brush border (B.B), lumen (L) and mitochondrion (M).

Fig 3 : Control Distal tubule (1 x 3,000)
Note normal nuclei (N), lumen (L) and intact mitochondria.

Fig 4 : Control collecting tubule (1x 2,000)
Note intact luminal border (single arrows), normal nuclei (N), mitochondria (M) and basal membrane (double arrow).

Fig 5 : Control mitochondria (1x 10,000)
Note normal mitochondria (M) and (Ma)

Fig 6 : Normal blood capillary (1 x 4,000)
Note intact capillary endothelium (En), and normal capillary lumen (Cp.L).
CAPTIONS TO FIGURES

PLATE 13:

Fig 1: Mammalian distal tubule (1 x 15,000).
Note spherical and oblong mitochondria (M) with cytoplasmic channels encompassing the mitochondria (arrow).

Fig 2: Reptilian distal tubule (1 x 30,000).
Note spherical mitochondria (M) also note parallel cristae running from one end to the other (arrow) and cytoplasmic channels found between mitochondrial rows but not covering the mitochondria (double arrows).
the tubule cytoplasm. The luminal space is slightly larger than distal tubule. (Plate 12 : Fig 4).

Under electron microscopy intact mitochondria show prominent cristae without vacuolisation in mitochondrial matrix (Plate 12 : Fig 5) and capillary endothelium with undisturbed and undamaged capillary endothelial cells. (Plate 12 : Fig 6). In Plate 12 : Fig 5 the mammalian and reptilian mitochondria are shown. 'Ma' indicates the reptilian mitochondria and 'M' indicates the mammalian mitochondria.

Mammalian and reptilian distal tubules can be indentified by the nature of mitochondria and the position of cytoplasmic channels. In mammalian distal tubules, the mitochondria are spherical and oblong with cytoplasmic channels (Plate 13 : Fig 1) encompassing them, where as the reptilian distal tubules show spherical mitochondria with cristae running parallel from one end to the other end. Cytoplasmic channels were flanked by the mitochondria. These did not cover the mitochondria (Plate 13 : Fig 2).

A) ULTRA STRUCTURAL ALTERATIONS IN GLOMERULUS UNDER THE INFLUENCE OF MINING EFFLUENTS:

The mallards exposed to 0.01% mining effluents (M.E.) did not exhibit any significant ultra structural change in glomerulus up to the end of twenty nine days, but at the end of thirty days, significant ultra structural changes in glomerulus were observed. The damaged glomerulus showed fused foot processes, thickening and distortion of basement membrane (Plate 14 : Fig 1). Reduction of endothelial cell size followed by endothelial sclerosis, change in the shape of red blood cells, widening of basement membrane, vacuolisation of cytoplasm in podocyte and discontinous basement membrane was also observed (Plate 14 : Fig 2, Plate 15 : Fig 1 and 2).
CAPTIONS TO FIGURES

PLATE 14:

Fig 1: 0.01% M. E. - 720 hours - Glomerulus - (1 x 5000).
Note the fusion of epithelial foot processes (F), thickening of basement membrane (B.M) and distorted basement membrane (double arrows). Also note normal mesangial (M.E.), capillary lumen (Cp. L).

Fig 2: 0.01% M. E. - 720 hours - Glomerulus (1 x 4,000).
Note endothelial sclerosis (En) and reduction of endothelial cell size. (double arrow).
CAPTIONS OF FIGURES

PLATE 15:

Fig 1: 0.01% M. E. - 720 hours - Glomerulus (1 x 6,000).

Note irregular basement membrane (B.M), and swollen epithelial cell (podocyte), (P), vacuolisation (v).

Fig 2: 0.01% M. E. - 720 hours - Glomerulus (1 x 10,000).

Note the discontinuous and slightly irregular basement membrane (B.M).
The 0.1% M.E. at the end of six hours promoted swelling of podocytes, vacuolisation of cytoplasm of podocyte, mitochondrial damage in podocytes (Plate 19 : Fig 1), vacuolisation of the foot process, increased Bowman's space, and irregular and distorted basement membrane (Plate 19 : Fig 2). 0.1% of M.E. also induced fusion of foot processes, increase in Bowman's space with microvilli in the Bowman's space and smoothening of capillary endothelium followed by endothelial sclerosis (Plate 20 : Fig 1 and 2) in glomerulus respectively.

Under the influence of 1.0% M.E. at the end of six hours ducks showed ultrastructural damage in glomerulus.

Mesangial proliferation also known as diffused proliferative glomerulonephritis along with fusion of foot process (Plate 24 : Fig 1) was observed in some glomeruli. In some glomeruli damaged basement membrane, increased Bowman's space along with microvilli in the space (Plate 24 : Fig. 2), endothelial sclerosis with damaged and irregular capillary basal membrane (Plate 25 : Fig.1) and mesangial proliferation with damaged endothelium and increased Bowman's space (Plate 25 : Fig 2) were observed.

The 5.0% M.E. induced ultrastructural damage in glomeruli. Focal glomerular sclerosis with complete loss of foot processes fused foot processes and increase in Bowman's space (Plate 30 : Fig 1) were observed. Thickening of outer wall of Bowman's capsule, increase in Bowman's space, thickening of basement membrane and smoothening of capillary endothelium (Plate 30 : Fig.2) were also observed in some glomeruli.

The ducks exposed to 10.0% M.E. showed significant alterations in glomeruli. At the end of six hours, complete loss of foot processes, mesangial proliferation thickening of basement membrane, irregularity in basement membrane, vacuolisation of cytoplasm in podocyte and thickening of outerwall of Bowman's capsule followed by increase in Bowman's space (Plate 34 :
Fig.1) were observed in many glomeruli. Capillary - Scleroderma along with swelling in podocyte was seen in some glomeruli (Plate 34 : Fig 2).

The mallards exposed to 50.0% M.E. exhibited maximum ultra structural changes in glomeruli. Focal glomerular sclerosis was observed in many glomeruli. Fusion of foot processes, swelling of podocytes, increase in Bowman's space with occurrence of microvilli in Bowman's space and sclerosis of capillary endothelium was more prominent (Plate 38 : Fig 1). Few glomeruli showed mesangial glomerulonephritis where, mesangial proliferation vacuolisation of cytoplasm in podocyte and capillary endothelial sclerosis were also seen (Plate 38 : Fig 2).

The 100.0% M.E. also induced ultra structural alterations in glomeruli. Membranous glomerulonephritis, along with fused foot processes, increased Bowman's space, microvilli in Bowman's space and swelling of podocytes (Plate 41 : Fig 2) were observed in many glomeruli. Endothelial sclerosis, scleroderma were also observed in some glomeruli (Plate 41 : Fig 2).

B] ULTRA STRUCTURAL CHANGES IN PROXIMAL TUBULES UNDER THE INFLUENCE OF MINING EFFLUENTS (M.E.):

The alterations in the ultrastructure of proximal tubules (PT) were similar when the ducks were exposed to different concentrations of M.E. for various time intervals. Hence, these are described together. For all the concentrations of M.E. there were insignificant changes in proximal tubules before 6 hours, but at the end of six hours necrosis was progressive and involved more tubules as the time progressed.

The birds exposed to 0.01% M.E. showed no significant alterations in PT upto the end of twentynine days. But at the end of thirty days (seven hundred and twenty hours), proximal tubules showed disrupted brush border, empty
CAPTIONS TO FIGURES

PLATE 16:

Fig 1: 0.01% M. E. - 720 hours - Proximal tubule (1 x 6,000).
Note the disrupted brush border (D.B.B), empty lysosomal vesicles (Ly), Nucleus (N) with dispersed chromatin material and tissue debris (Tb) in lumen (L).

Fig 2: 0.01% M. E. - 720 hours - Distal tubule (1 x 6000).
Note Vacuolisation of cytoplasm (V), swollen Golgi bodies (G) and heavy metal deposition in the nucleus (H.M).
CAPTIONS TO FIGURES

PLATE 17:

Fig 1: 0.01% M. E. - 720 hours - Distal tubule (1 x 5,000).

Note the lipid droplets in distal tubule (Lp), swelling of tubule with reduction in luminal space (L), pyknotic nucleus (N) with heavy metal depositions (H.M.) and dispersed chromatin (C) in the nucleus.

Fig 2: 0.01% M. E. - 720 hours - Distal tubule (1 x 20,000).

Note the damaged mitochondria (M) from the Distal tubules.
CAPTIONS TO FIGURES

PLATE 18:

Fig 1: 0.01% M. E. - 720 hours - Distal tubule (1 x 3,000).

Note the swollen tubule (DT), tissue debris (Tb) in the lumen (L), nucleus pycnotic and dispersed chromatin.

Fig 2: 0.01% M. E. - 720 hours - Collecting tubule (1 x 2,000).

Note distorted collecting tubule (C.T.D) mitochondria (M) along with nucleus (N) released in the lumen (L). Also note Red blood cells (RBC) in the lumen (L) and damaged Basal membrane of the tubule (double arrow).
CAPTIONS TO FIGURES

PLATE 21:

Fig 1: 0.1% M. E. - 6 hours - Proximal tubule (1 x 5,000).
Note the vacuolisation of cytoplasm (V) and damaged mitochondria (M). Also note brush border (B.B).

Fig 2: 0.1% M. E. - 6 hours - Proximal tubule (1 x 10,000).
Note the empty lysosomal vesicles (Ly). Vacuolisation of cytoplasm (V) and heavy metal depositions (H.E) in the tubule cytoplasm. Also note damaged mitochondrion (M).
CAPTIONS TO FIGURES

PLATE 22:

Fig 1: 0.1% M. E. - 6 hours - Distal tubule (1 x 2,000).
Note the distorted and swollen distal tubule (D.D.T), pycnotic nucleus (N), reduced luminal space (L) and deposition of lipid droplets (Lp).

Fig 2: 0.1% M. E. - 6 hours - Distal tubule (1 x 8,000).
Note the proliferation of Golgi bodies and damaged mitochondrion (M).
CAPTIONS TO FIGURES

PLATE 19:

Fig 1: 0.1% M. E. - 6 hours - Glomerulus - (1 x 6,000).
Note the swollen podocyte (P), vacuolisation of cytoplasm in podocyte (V) and damaged mitochondria (M).

Fig 2: 0.1% M. E. - 6 hours - Glomerulus (1 x 20,000).
Note the discontinuous and irregular basement membrane (B.M), Increase in Bowman's Space (U), and Vacuolisation of foot processes (V).
CAPTIONS TO FIGURES

PLATE 20:

Fig 1: 0.1% M. E. - 6 hours - Glomerulus (1 x 10,000).

Note the focal glomerular sclerosis, complete loss of foot processes (double arrows), increase in Bowman's space (U) and numerous microvilli (mv) in the Bowman's space.

Fig 2: 0.1% M. E. - 6 hours - Glomerulus (1 x 6,000).

Note smooth and discontinuous capillary endothelium (En), and endothelial sclerosis (double arrows).
CAPTIONS TO THE FIGURES

PLATE 1:

Fig 1: Control. (10 x 5)
Note the intact glomerulus (GL); intact proximal tubule (PT), intact distal tubule (DT) and intact collecting tubule (CT).

Fig 2: 0.01% M. E. - 720 hours. (10 x 5)
Note the change in the shape of the glomerulus (Arrow). Also note the damaged glomerulus (G) with exudents in Bowman’s space. Note the damaged proximal tubules (PT) with the exudation of the nuclei into the empty space. Note the damaged distal tubule (DT) and collecting tubule (CT).

Fig 3: 0.01% M. E. - 1080 hours. (20 x 5)
Note the damaged glomerulus (G), distorted proximal tubule (PT), damaged distal tubule (DT) and distorted collecting tubule (CT).

Fig 4: 0.1% M. E. - 6 hours. (10 x 5)
Note the damaged glomerulus (G) with exudents in the Bowman’s space, proximal tubule (PT), damaged distal tubule (DT) and loss of architecture of a few collecting tubules (CT).
CAPTIONS TO FIGURES

PLATE 23:

Fig 1: 0.1% M. E. - 6 hours - Collecting tubule (1 x 2,000).

Note the damaged collecting tubule (D.C.T) pycnotic nucleus (N) with heavy metal depositions (H.M), distorted basal membrane (double arrows), mitochondria (M) in the luminal space and vacuolisation of cytoplasm (V).

Fig 2: 0.1% M. E. - 6 hours - Collecting tubule (1x 20,000).

Note the vacuolisation in the mitochondrion (V).
CAPTIONS OF FIGURES

PLATE 24:

Fig 1: 1.0% M. E. - 6 hours - Glomerulus (1 x 2,000).
Note the diffused proliferative glomerulonephritis, mesangial proliferation (M.E.P) and complete loss of foot process (double arrows), capillary lumen (Cp.L) and podocyte (P).

Fig 2: 1% M. E. - 6 hours - Glomerulus (1 x 8,000).
Note the fused foot processes (F), increased Bowman's space (U), microvilli (mv) in the Bowman's space, damaged basement membrane (B.M) and distorted capillary endothelium (En).
CAPTIONS TO FIGURES

PLATE 25:

Fig 1: 1% M. E. - 6 hours - Blood capillary (1 x 2000).

Note the scleroderma of capillary endothelium. Capillary endothelium thickening (arrows), smoothening of capillary endothelium (double arrows) and irregularity of capillary basal membrane (I.B.m).

Fig 2: 1% M. E. - 6 hours - Glomerulus (1 x 6000).

Note the mesangial proliferation (Me.P), fused foot processes (double arrows), increase in Bowman's space (U) and endothelial sclerosis (En).
CAPTIONS TO FIGURES

PLATE 26:

Fig 1: 1% M. E. - 6 hours - Proximal tubule (1 x 2,000).

Note the swelling of proximal tubule (P.T), brush border (double arrows) occupying the whole lumen, heavy metal (H.M.), depositions in cytoplasm, vacuolisation of cytoplasm (V), distortion of chromatin material in the nucleus (N) and empty lysosomal vesicles (Ly).

Fig 2: 1% M. E. - 6 hours - Proximal tubule (1 x 10,000).

Note the disrupted brush border (D.B.B.) and tissue debris (Tb) in the lumen.
CAPTIONS TO FIGURES

PLATE 27:

Fig 1: 1% M. E. - 6 hours - Distal tubule - (1 x 4,000).

Note the lipid (Lp) droplets, vacuolisation of cytoplasm (V), swollen Golgi bodies. Also note autophagic vacuoles (double arrows) and pycnotic nuclei (N).

Fig 2: 1% M. E. - 6 hours - Distal tubule (1 x 8,000).

Note the separation of two cells (double arrows). Nucleus with dispersed chromatin (arrow).
CAPTIONS TO FIGURES

PLATE 28:

Fig 1: 1% M. E. - 6 hours - Distal tubule (1 x 2,000).

Note tissue debris (Tb) in the lumen (L), deposition of lipid droplets, pycnotic nucleus (N) and vacuolisation (V) of the cytoplasm.

Fig 2: Note 1% M. E. - 6 hours - Distal tubule (1 x 3,000).

Note the proliferation of Golgi bodies (Gg), damaged mitochondria (M) and distorted basal membrane (double arrow).
lysosomal vesicles, nucleus with dispersed chromatin material and tissue debris in the lumen (Plate 16 : Fig 1). The ducks exposed to 0.1% to 100% M.E. exhibited pronounced necrosis of PT and most of the necrotic changes mentioned for 0.01% M.E. exposure were seen, but in addition, the alterations such as vacuolisation of the cytoplasm, destruction of mitochondria, deposition of heavy metals in the cytoplasm, swelling of PT, shedding of brush border into the lumen, covering the entire lumen and tissue debris along with damaged mitochondria in the lumen were observed (Plate 21 : Fig 1 and 2, Plate 26 : Fig 1 and 2, Plate 31 : Fig 1 and 2, Plate 35 : Fig 1 and 2, Plate 39 : Fig 1 and Plate 42 : Fig 1 and 2).

The degree of necrosis with different concentrations of M.E. changed at later hours, and the number of damaged tubules increased as the exposure period increased.

C] ULTRA STRUCTURAL ALTERATIONS IN DISTAL TUBULES (DT):

The birds exposed to 0.01% M.E. also induced ultrastructural alterations in DT. Mallards did not exhibit any significant change in DT before seven hundred and twenty hours (twenty nine days), when exposed to 0.01% M.E. But at the end of seven hundred and twenty hours (thirty days) the alterations in DT became more significant and prominent. The DT showed necrotic changes such as vacuolisation of cytoplasm, swelling of Golgi bodies, heavy metal deposition in the pycnotic nucleus, deposition of lipids in the cytoplasm, swelling of DT with reduction of luminal space and dispersed chromatin in the nucleus (Plate 16 : Fig 2, Plate 17 : Fig 1 and 2). Tissue debris in the lumen along with distorted luminal border was also observed (Plate 18 : Fig 1).

When the mallards were introduced to various concentrations of M.E. (0.1 to 100%) they showed alterations in DT similar to those described for
0.01% M.E. with variations in the degree of necrosis. The variations in necrosis were such as proliferation of Golgi bodies (Plate 22: Fig 2), formation of autophagic vacuoles (Plate 27: Fig 1), separation of tubule cells (Plate 27: Fig 2), occurrence of tissue debris in the tubular lumen. (Plate 28: Fig 1, Plate 32: Fig 1 and 2), damaged basal membrane of the tubule (Plate 28: Fig 2, Plate 40: Fig 1), heavy deposition of lipid droplets in cytoplasm and heavy metal depositions in nuclei (Plate 36: Fig 1 and 2, Plate 39: Fig 2, Plate 32: Fig 2) were also seen in few tubules. Some tubules showed complete distortion of luminal border and damaged mitochondria (Plate 22: Fig 1, Plate 43: Fig 1 and 2). Swelling of Golgi bodies was also observed in few tubules (Plate 28: Fig 2).

All the above mentioned alterations were also observed in later hours involving increase in the number of distal tubules undergoing necrosis and the tubules became acutely necrotic when exposed to the M.E. chronically.

ULTRA STRUCTURAL CHANGES IN COLLECTING TUBULES: (CT)

The ducks exposed to various concentrations of mining effluents (0.1 to 100%) showed necrosis of collecting tubules at the end of six hours. Only 0.01% M.E. did not exhibit any significant change in collecting tubules up to the end of twenty nine days. By the end of seven hundred and twenty hours (thirty days) the tubules showed necrosis. The 0.01% M.E. induced alterations such as complete distortion of few collecting tubules exudation of nuclei along with tissue debris in the lumen, distortion of basal membrane of the collecting tubules and exudation of red blood cells in the lumen of distorted tubule (Plate 18: Fig 2) were observed.

The mallards when exposed to 0.1 to 100% M.E. showed alterations in collecting tubules such as, distortion of basal membrane, pycnosis of nuclei
Fig 1: 1% M. E. - 6 hours - Collecting tubule (1 x 2,000).
Note the pycnotic nuclei (N), with heavy metal (H.M) depositions. Lipid deposits (Lp), vacuolisation of cytoplasm (V) and tissue debris (Td) in the lumen (L).

Fig 2: 1% M. E. - 6 hours - Collecting tubule (1 x 10,000).
Note the damaged mitochondria (M) and cytoplasmic vacuolisation (V).
CAPTIONS TO FIGURES

PLATE 30:

Fig 1: 5% M. E. - 6 hours - Glomerulus (1 x 6,000).
Note the thickening of basement membrane (double arrow), fused foot processes (F) and increased Bowman's space (U).

Fig 2: 5% M. E. - 6 hours - Glomerulus (1 x 5,000).
Note the increase in the Bowman's space (U), thickening and irregular outer Bowman's capsule membrane (B.W). Thickening of basement membrane (B.M) and smoothening of endothelium (double arrows).
CAPTIONS TO FIGURES

PLATE 31 :

Fig 1 : 5.0% M. E. - 6 hours - Proximal tubule (1 x 5,000).
Note the vacuolisation of cytoplasm (V), empty lysosomal vesicles (Ly) and depositions of heavy metal (H.M).

Fig 2 : 5% M. E. - 6 hours - Proximal tubule (1 x 2500).
Note the damaged mitochondria (M).
CAPTIONS TO FIGURES

PLATE 32:

Fig 1: 5% M. E. - 6 hours - Distal tubule (1 x 3,000).
Note swollen distal tubule (DT) with reduced luminal (L) space; tissue debris in the lumen (Tb).

Fig 2: 5% M. E. - 6 hours - Distal tubule (1 x 6,000).
Note heavy metal depositions in the nucleus (H.M) and tissue debris in lumen (Tb). Also note autophagic vacuoles (double arrows).
CAPTIONS TO FIGURES

PLATE 33:

Fig 1: 5% M. E. - 6 hours - Collecting tubule (1 x 2,300).
Note swollen collecting tubule (CT), reduced luminal space (L) (double arrows) and Pycnotic nucleus (N). Also note large deposits of lipid (Lp).

Fig 2: 5% M. E. - 6 hours - Collecting tubules (1 x 2,000).
Note damaged mitochondria (M) from collecting tubules.
CAPTIONS TO FIGURES

PLATE 34:

Fig 1: 10% M. E. - 6 hours - Glomerulus (1 x 2,000).

Note the thickening of Bowman's capsular outer wall (B.W), increase in Bowman's space (U), irregular and thickened basement membrane (B.M), mesangial proliferation (Me.P). Also note vacuolisation of cytoplasm in podocyte and complete loss of foot processes (double arrows).

Fig 2: 10% M. E. - 6 hours - Glomerulus (1 x 4,000).

Note the swollen podocyte (P), scleroderma, thickening and slight irregular capillary basement membrane (double arrow). Also note smoothening of capillary endothelium (arrows).
CAPTIONS TO FIGURES

PLATE 35 :

Fig 1: 10% M. E. - 6 hours - Proximal tubule (1 x 4,000).

Note the empty lysosomal vesicles (Ly), cytoplasmic vacuolisation (V) and the Nucleus (N) with dispersed chromatin. Also note brush border (B.B).

Fig 2: 10% M. E. - 6 hours - Proximal tubule (1 x 2,000).

Note the disrupted brush border (D.B.B.), tissue debris in lumen (Tb) and red blood cells in interstitium (RBC).
CAPTIONS TO FIGURES

PLATE 36:

Fig 1: 10% M. E. - 6 hours - Distal tubule (1 x 2,000).

Note the swollen tubule, lipid deposits (Lp), reduced luminal space (L), pycnotic nucleus (N) and vacuolisation of cytoplasm (V). Also note increase in inter tubular space (Ts).

Fig 2: 10% M. E. - 6 hours - Distal tubule (1 x 3,000).

Note the damaged mitochondria (M) and pycnotic nucleus (N) with heavy metal deposition (H.M).
CAPTIONS TO FIGURES

PLATE 37:

Fig 1: 10% M. E. - 6 hours - Collecting tubule (1 x 2,000).
Note the damaged luminal border (double arrows), cytoplasmic vacuolisation (V), pycnotic nucleus (N), with heavy metal (H.M) depositions.

Fig 2: 10% M. E. - 6 hours - Collecting tubules (1 x 30,000).
Note the damaged mitochondria (M).
CAPTIONS TO FIGURES

PLATE 38 :

Fig 1 : 50% M. E. - 6 hours - Glomerulus ( 1 x 4,000 ).
Note the swollen podocyte (P), fused foot processes, increase in
Bowman's space (U), microvilli in Bowman's space (mv) and sclerosis
of capillary endothelium (double arrows).

Fig 2 : 50% M. E. - 6 hours - Glomerulus ( 1 x 4,000 ).
Note the mesangial proliferation, swollen podocyte (P), fused foot
processes (F) and damaged capillary endothelium (En).
CAPTIONS TO FIGURES

PLATE 39:

Fig 1: 50% M. E. - 6 hours - Proximal tubule (1 x 5,000).
Note swelling of proximal tubule, brush border acquiring the entire lumen (double arrows), cytoplasmic vacuolisation (v), empty lysosomal vesicles (Ly) and heavy metal depositions in tubules (H.M).

Fig 2: 50% M. E. - 6 hours - Distal tubule (1, x 2,000).
Note the lipid droplets (Lp), vacuolisation of cytoplasm, swelling of tubule with reduced luminal space (L) and pycnotic nucleus (N) with heavy metal depositions. (H.M).
CAPTIONS TO FIGURES

PLATE 40:

Fig 1: 50% M. E. - 6 hours - Distal tubule (1 x 4,000).

Note damaged basal membrane double arrows, heavy metal (H.M.) deposition in pycnotic nuclei (N) and deposition of lipid droplets (Lp).

Fig 2: 50% M. E. - 6 hours - Collecting tubule (1 x 4,000).

Note distorted collecting tubule, swollen Golgi bodies (Gg) in the lumen (L), lipid droplets deposition (Lp), discontinous basal membrane (double arrows), pycnotic nucleus (N) with heavy metal (H.M) deposition. Vacuolisation of cytoplasm and damaged mitochondria (M).
CAPTIONS TO FIGURES

PLATE 41 :

Fig 1: 100% M. E. - 6 hours - Glomerulus (1 x 3,000).
Note the swollen podocyte (P), fused foot processes (F), and irregular and thickened basement membrane (double arrow). Also note microvilli (mv) in Bowman's space.

Fig 2: 100% M. E. - 6 hours - Glomerulus (1 x 4,000).
Note endothelial sclerosis (arrow), increase in Bowman's space (U), and scleroderma of capillary endothelium (double arrows). Also note capillary lumen (CpL).
CAPTIONS TO FIGURES

PLATE 42 :

Fig 1: 100% M. E. - 6 hours - Proximal tubule (1 x 4,000).

Note the disruption of brush border (double arrow), damaged mitochondrion (M) in lumen (L), vacuolisation of cytoplasm (V) and heavy metal deposition (H.M).

Fig 2: 100% M. E. - 6 hours - Proximal tubule (1 x 10,000).

Note the empty lysosomal vesicles (Ly) and cytoplasmic vacuolisation (V).
CAPTIONS TO FIGURES

PLATE 43:

Fig 1: 100% M. E. - 6 hours - Distal tubule (1x 2,000).
Note the pycnotic nucleus (N) with deposition of heavy metal (H.M), reduced luminal space (L) due to swelling, distorted luminal border (double arrows) and tissue debris in the lumen (Tb).

Fig 2: 100% M. E. - 6 hours - Distal tubule (1x 25,000).
Note the damaged mitochondrion (M).
CAPTIONS TO FIGURES

PLATE 44:

Fig 1: 100% M. E. - 6 hours - Collecting tubule (1 x 2,000).
Note the heavy deposition of lipid (Lp), pycnotic nuclei (N) with heavy metal deposition and reduced luminal (L) space.

Fig 2: 100% M. E. - 6 hours - Collecting tubule (1 x 15,000).
Note the damaged mitochondria (M).
CAPTIONS TO FIGURES

PLATE 45:

Fig 1: 100% M. E. - 6 hours - Collecting tubule (1 x 5,000).
Note the Endoplasmic Reticuler proliferation (E.R.P) and vacuolisation of cytoplasm.

Fig 2: 100% M. E. - 6 hours - Collecting tubules (1 x 5,000).
Note the decrease in luminal space (L), exudation of Golgi bodies in lumen (Gg), vacuolisation of cytoplasm, deposition of heavy metal (H.M.) in nucleus and ciliary processes with E.R. in lumen (Cp). Also note the vacuolisation of the cytoplasm.
deposition of heavy metals in the nuclei (Plate 23 : Fig 1), vacuolisation of mitochondria (Plate 23 : Fig 2), heavy deposition of lipid droplets along with mitochondrial damage (Plate 29 : Fig 1 and 2, Plate 33 : Fig 1 and 2, Plate 40 : Fig 2). Swelling of collecting tubules with reduction in luminal space (Plate 33 : Fig 1), damaged luminal border (Plate 37 : Fig 1) and swelling of Golgi bodies (Plate 40 : Fig 2) were also observed.

Maximum alterations in collecting tubules were observed with 100% M.E. where proliferation of endoplasmic recticulum was most prominent, ciliary processes and Golgi profiles were exuded in the lumina of the tubules (Plate 45 : Fig 1 and 2). The degree of necrosis altered when exposure periods were prolonged. The chronic exposures to M.E. promoted increased involvement of the collecting tubules in the process of necrosis.
III] HISTOCHEMICAL ALTERATIONS :

A] ACID PHOSPHATASE :

When different histochemical techniques were employed for the studies of acid phosphatase, the technique of Davies and Ornstein (1959) using α-napthyl phosphate as substrate and fast garnet GBC as azodye was found suitable. The studies on acid phosphatase of mallards revealed the presence of two types of renal tubules. One type of renal tubule showed the presence of brush/luminal border and cytoplasmic acid phosphatase and the other showing cytoplasmic acid phosphatase. For the sake of convenience the tubules showing brush/luminal border enzyme activity would be referred as 'BL' type and others showing cytoplasmic enzyme activity as 'Cy' types. It is already established that the avian kidney is composed of mammalian and reptilian tubules. It is very difficult to say whether the mammalian tubules are showing brush/luminal border acid phosphatase or the reptilian ones. It is observed that about sixty percent tubules exhibited brush/luminal border acid phosphatase while about forty percent tubules showed the cytoplasmic acid phosphatase.

The ducks exposed to the mining effluents (M.E.) also showed the acid phosphatase activity bound to the membranes. Thus, the present investigation revealed the presence of three types of acid phosphatase brush/luminal border, cytoplasmic and membrane bound based on the locations. The brush/luminal border acid phosphatase activity in controls was quite high and as a result the azodye staining diffused into lumina, thereby filling them (Plate 46 : Fig 1). A few glomeruli also showed the acid phosphatase activity. In the tubules the lysosomal granular acid phosphatase activity was masked by cytoplasmic staining and this was confirmed by the enzyme activation and inhibition studies.
CAPTIONS TO FIGURES

PLATE 46:

Fig 1: Control: Acid phosphatases (A P) - α napthyl - Fast Garnet GBC (Davies & Ornstein, 1959). (10 x 5)
Note selective brush border (PT) and luminal (DT) enzyme activity. Also note diffused cytoplasmic activity with brush/luminal border activity in other tubules (dashed arrows). No enzyme activity in collecting tubules (CT), except in few nuclei.

Fig 2: 0.01% M. E. - 720 hours - (A P) - α napthyl - Fast Garnet GBC.
(10 x 5)
Note increase in the enzyme activity in the brush border/luminal border (PT/DT) of the tubules. Also note occurrence of acid phosphatases in the brush border/luminal border (arrow) of the tubules previously showing cytoplasmic staining.

Fig 3: 0.01% M. E. - 1080 hours - (A P) - α napthyl - Fast Garnet GBC.
(10 x 5)
Note further increase in the acid phosphatase activity in the brush border/luminal border (arrows) of both the types of tubules identified on the basis of stainability.

Fig 4: 0.1% M. E. - 6 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note increase in acid phosphatase activity at the brush and luminal borders (solid arrow). Also note the diffused fine granular cytoplasmic and brush/luminal border (dashed arrow) acid phosphatase activity in other tubules.
CAPTIONS TO FIGURES

PLATE 47:

Fig 1: 0.1% M. E. - 12 hours - (A P) - α napthyl - Fast Garnet GBC.
(10 x 5)
Note reduction in the enzyme activity at the brush/luminal borders (solid arrow) of tubules. Also note the slight reduction in the enzyme activity from the cytoplasm (dashed arrow) and brush / luminal border of the other type of tubules.

Fig 2: 0.1% M. E. - 48 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note the significant increase in the enzyme activity at the brush/luminal borders (solid arrow) of tubules. Also note increased cytoplasmic enzyme activity in other types of tubules (dashed arrows).

Fig 3: 0.1% M. E. - 72 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note intense enzyme activity at the brush/luminal (solid arrow) border of few tubules and they also show cytoplasmic enzyme activity. Also note the slight reduction in the cytoplasmic enzyme activity but increase in the brush/luminal (dashed arrow) border enzyme activity of other tubules. Note nuclear (N) enzyme activity.

Fig 4: 0.1% M. E. - 96 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note profound increase in the enzyme activity of the tubules at brush/luminal (solid arrow) borders and also note diffused enzyme activity with nuclear membrane (N) enzyme activity. Note the other types of tubules with increase in the cytoplasmic activity (dashed arrow).
The mallards exposed to 0.01 % M.E. did not exhibit any significant change in the histochemistry of acid phosphatase up to the end of twenty-nine days but by the end of thirty days an increase in the brush/luminal border acid phosphatase was seen and interestingly the 'Cy' tubules previously showing cytoplasmic acid phosphatase showed the appearance of brush/luminal border enzyme activity with the reduction in the cytoplasmic enzyme activity (Plate 46: Fig 2). At the end of one thousand and eighty hours, both the types of tubules exhibited increase in the brush/luminal border acid phosphatase activity. The glomeruli exhibited slight reduction in the enzyme activity. (Plate 46 - Fig 3).

Under the influence of 0.1% M.E. at the end of six hours, the tubules (proximal & distal) previously showing brush/luminal border acid phosphatase activity exhibited increase in the enzyme activity. The 'Cy' tubules showing cytoplasmic acid phosphatase activity showed increase in the cytoplasmic enzyme activity but in addition showed insignificant occurrence of brush/luminal border enzyme activity. Even the debris whenever present in the lumina of the tubules exhibited enzyme activity (Plate 46: Fig 4). At the end of twelve hours there was decrease in the brush/luminal border enzyme activity from all the tubules (Plate 47: Fig 1). But, at the end of forty-eight hours, there was once again increase in the enzyme activity at the brush/luminal borders of the "BL" tubules. Most of the 'Cy' tubules exhibited increase in the cytoplasmic enzyme activity in them but the 'Cy' type tubules now showed increase in the enzyme activity at the brush/luminal borders and decreased cytoplasmic activity (Plate 47: Fig 3). In a few tubules also the nuclear membranes showed the acid phosphatase activity.

The 0.1% M.E. induced profound increase in the brush/luminal border as well as cytoplasmic acid phosphatase activity in 'BL' type tubules while 'Cy' tubules showed loss of brush/luminal border acid phosphatase activity, few of these tubules showed decrease in the cytoplasmic enzyme activity (Plate 47: 114
CAPTIONS TO FIGURES

PLATE 48:

Fig 1: 0.1% M. E. - 120 hours - (A P) - α napthyl-Fast Garnet GBC. (10 x 5)
Note the reduction in the enzyme activity (solid and dashed arrow) in 'BL' type tubules. Also note weak enzyme activity in 'Cy' type tubules (C). Note absence of enzyme activity in collecting tubules (CT) and glomerulus(G).

Fig 2: 1.0% M. E. - 6 hours - (A P) - α napthyl - Fast Garnet GBC. (10 x 5)
Note increase in the enzyme activity at the brush/luminal (solid arrow) border of the tubules. Also note weak brush/luminal (dashed arrow) border enzyme activity in other types of tubules.

Fig 3: 1.0% M. E. - 24 hours - (A P) - α napthyl - Fast Garnet GBC. (10 x 5)
Note intense enzyme activity in the brush/luminal (solid arrow) borders of some tubules. Also note slight reduction in the brush/luminal (dashed arrow) border enzyme activity of other types of tubules. Also note the increase in number of tubules showing enzyme activity.

Fig 4: 1.0% M. E. - 72 hours - (A P) - α napthyl - Fast Garnet GBC. (20 x 5)
Note very intense enzyme activity in brush/luminal (solid arrow) borders. Also note increase in the cytoplasmic enzyme (dashed arrow) activity of the other tubules.
CAPTIONS TO FIGURES

PLATE 49 :

Fig 1: 1.0% M. E. - 96 hours - (A P) - α napthyl - Fast Garnet GBC.

(20 x 5)
Note slight reduction in the enzyme activity at brush/luminal (solid arrow) borders of tubules previously showing very intense enzyme activity. Also note slight reduction in the cytoplasmic enzyme (dashed arrows) activity of other tubules.

Fig 2: 1.0% M. E. - 120 hours - (A P) - α napthyl - Fast Garnet GBC.

(10 x 5)
Note further increase in the acid phosphatase activity at the brush/luminal (solid arrow) borders of the tubules and also cytoplasmic enzyme activity. Also note the return of brush/luminal (dashed arrow) border enzyme activity in 'Cy' type tubules. Glomerulus (G) without changed enzyme activity.

Fig 3: 5.0% M. E. - 12 hours - (A P) - α napthyl - Fast Garnet GBC.

(10 x 5)
Note brush/luminal (solid arrow) border enzyme activity. Also note increased cytoplasmic enzyme (dashed arrow) activity in other types of tubules.

Fig 4: 5.0% M. E. - 24 hours - (A P) - α napthyl - Fast Garnet GBC.

(20 x 5)
Note further increase in the brush/luminal (solid arrow) border enzyme activity. Also note the occurrence of brush/luminal (dashed arrow) border enzyme activity in other tubules.
Occasionally the necrotic tubules showed membrane acid phosphatase activity. The collecting tubule nuclei, exudents and basal membranes showed acid phosphatase activity in few cases (Plate 49: Fig 3 and 4). At the end of fortyeight hours there was no change in the enzyme activity. But at the end of seventytwo hours, there was reduction in the enzyme activity from all the tubules and a weak membrane acid phosphatase activity was seen on the basal membranes of a few necrotic tubules (Plate 50: Fig 2). Then, at onetwenty hours there was once again increase in the enzyme activity of all the tubules. The glomerulus (G) did not show any significant change in the enzyme activity. In 'Cy' type tubules a very weak brush/luminal border acid phosphatase activity was seen (Plate 50: Fig 3).

The ducks exposed to 10.0% M.E. exhibited intense staining in 'BL' type tubules and increased brush/luminal border activity in 'Cy' type tubules (dashed arrow, PT) (Plate 50: Fig 4). At the end of twelve hours there was a little increase in the acid phosphatase activity of all the tubules but, at the end of twentyfour hours the 'BL' type tubules showed increase at the brush/luminal borders; also cytoplasmic enzyme activity from these tubules increased. The 'Cy' type tubules exhibited increase in the cytoplasmic acid phosphatase activity and in a few tubules the brush/luminal border enzyme activity appeared. The widened interstitium was without the enzyme activity (Plate 51: Fig. 1).

At the end of fortyeight hours the acid phosphatase activity at the brush/luminal borders of the 'BL' type tubules increased significantly and these tubules showed fine granular and cytoplasmic enzyme activity. The 'Cy' type tubules showed reduction in the cytoplasmic acid phosphatase activity and a very few of these tubules showed brush/luminal border acid phosphatase. In few places the exudents in the interstitium showed enzyme activity (Plate 51: Fig 2). By the end of ninetysix hours the acid phosphatase activity from the 'BL' and 'Cy' type tubules reduced at the brush/luminal borders but cytoplasmic
CAPTIONS TO FIGURES

PLATE 51:

Fig 1: 10.0% M. E. - 24 hours - ( A P ) - α napthyl - Fast Garnet GBC.  
( 20 x 5 )
Note increase in the enzyme activity at brush/luminal (solid arrow) border of the tubules which also show cytoplasmic enzyme activity. Also note slight increase in the cytoplasmic enzyme activity of other tubules showing occurrence of brush/luminal (dashed arrow) border activity.

Fig 2: 10.0% M. E. - 48 hours - ( A P ) - α napthyl - Fast Garnet GBC.  
( 20 x 5 )
Note intense enzyme activity at the brush/luminal (solid arrow) borders of tubules which also show cytoplasmic enzyme activity. Also note the occurrence of brush/luminal (dashed arrow) border enzyme activity in other tubules and also note the increase in the enzyme activity of these tubules.

Fig 3: 10.0% M. E. - 96 hours - ( A P ) - α napthyl - Fast Garnet GBC.  
( 20 x 5 )
Note reduction in the enzyme activity at the brush/luminal (solid arrow) border of the tubules. Also note slight reduction at the brush/luminal (dashed arrow) border enzyme activity of other tubules where now increased cytoplasmic enzyme activity is seen.

Fig 4: 10.0% M. E. - 120 hours - ( A P ) - α napthyl - Fast Garnet GBC.  
( 10 x 5 )
Note increase in the enzyme activity at the brush/luminal (solid arrow) borders of the tubules. Also note increased enzyme activity at the brush/luminal (dashed arrow) borders of the other tubules. Also note occurrence of enzyme activity at the basal membranes (B) of the tubules.
CAPTIONS TO FIGURES

PLATE 52:

Fig 1: 50.0% M. E. - 6 hours - (A P) - α napthyl - Fast Garnet GBC.
(10 x 5)
Note intense enzyme activity in few tubules (solid arrow). Also note weak cytoplasmic (dashed arrow) enzyme activity.

Fig 2: 50.0% M. E. - 12 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note the very intense enzyme activity in the tubules (solid arrow). Also note the appearance of enzyme activity in glomerulus (G) and the dense granular enzyme activity in other tubules.

Fig 3: 50.0% M. E. - 24 hours - (A P) - α napthyl - Fast Garnet GBC.
(10 x 5)
Note the slight reduction in the enzyme activity of the tubules (solid arrow). Also note increase in the cytoplasmic enzyme activity of other tubules (dashed arrow). Note increase in glomerular (G) enzyme activity.

Fig 4: 50.0% M. E. - 48 hours - (A P) - α napthyl - Fast Garnet GBC.
(20 x 5)
Note further reduction in the enzyme activity of the tubules previously showing intense activity (solid arrow) Also note reduction in the cytoplasmic enzyme activity of other tubules (dashed arrow) but few of these tubules show brush/luminal border enzyme activity.
acid phosphatase from the 'Cy' tubules increased except for about ten percent tubules where the cytoplasmic enzyme activity reduced. (Plate 51 : Fig 3). Then, at the end of one twenty hours, the acid phosphatase activity at the brush/luminal borders from the 'BL' type tubules increased and the cytoplasm of these tubules showed weak enzyme activity. The 'Cy' type tubules showed slight increase at the brush/luminal borders. A few tubules from both types showed membrane acid phosphatase activity (Plate 51 : Fig 4).

The ducks exposed to 50.0 % M.E. showed intense brush/luminal border activity in the 'BL' type tubules at the end of six hours while 'Cy' type tubules showed a weak cytoplasmic acid phosphatase activity. Also the cytoplasmic enzyme activity in the 'BL' type tubules was increased a little in few tubules. The exudents in the interstitium exhibited acid phosphatase activity (Plate 52 : Fig.1). By the end of twelve hours there was further increase in the enzyme activity at the brush/luminal borders of the 'BL' type tubules along with the increase in the cytoplasmic acid phosphatase activity. The 'Cy' type tubules showed large granular staining in the tubules and the luminal exudents showed acid phosphatase activity. The necrotic glomeruli showed increase in the enzyme activity (Plate 52 : Fig 2).

At the end of twentyfour hours there was reduction in the enzyme activity at the brush/luminal borders of 'BL' type tubules, while the 'Cy' type tubules showed slight increase in the cytoplasmic activity. The glomeruli showed slight increase in the enzyme activity (Plate 52 : Fig 3). By the end of fortyeight hours the number of 'BL' tubules showing intense activity decreased and these tubules showed the reduced acid phosphatase activity. A few 'Cy' type tubules showed reduction in cytoplasmic enzyme activity with the occurrence of very weak brush/luminal enzyme activity. Some of the other tubules of 'Cy' type exhibited slight increase in the enzyme activity (Plate 52 : Fig 4). At the end of ninetysix hours there was once again increase in the enzyme activity at the brush/luminal borders of the 'BL' type tubules while, the 'Cy' type tubules.
CAPTIONS TO FIGURES

PLATE 53:

Fig 1: 50.0% M. E. - 96 hours - ( A P ) - α napthyl - Fast Garnet GBC. (10 x 5)
Note increase in the brush/luminal (solid arrow) border enzyme activity. Also note the increase in the brush/luminal (dashed arrow) border enzyme activity of 'Cy' tubules. Also note the enzyme activity in the exudents (E).

Fig 2: 50.0% M. E. - 120 hours - ( A P ) - α napthyl - Fast Garnet GBC. (10 x 5)
Note slight reduction in the enzyme activity of some tubules (solid arrow). Also note reduction in the cytoplasmic enzyme activity of most of the tubules (dashed arrow).

Fig 3: 100.0% M. E. - 6 hours - ( A P ) - α napthyl - Fast Garnet GBC. (20 x 5)
Note intense enzyme activity in some tubules (solid arrow) at the brush/luminal border. Also note the increased cytoplasmic activity in general. Note brush/luminal border enzyme activity in 'Cy' tubules (Cy - dashed arrow).

Fig 4: 100.0% M. E. - 24 hours - ( A P ) - α napthyl - fast Garnet GBC. (10 x 5)
Note high enzyme activity at the brush/luminal (solid arrow) borders of the tubules. Also note increase in the granular lysosomal staining (dashed arrow).
CAPTIONS TO FIGURES

PLATE 54 :

Fig 1 : 100.0% M. E. - 48 hours - ( A P ) - α napthyl - Fast Garnet GBC. ( 10 x 5 )
Note high enzyme activity at the brush/luminal (solid arrow) borders of the tubules. Also note the occurrence of granular lysosomal staining (dashed arrow) in some tubules.

Fig 2 : 100.0% M. E. - 72 hours - ( A P ) - α napthyl - Fast Garnet GBC. ( 10 x 5 )
Note reduction in the acid phosphatase activity from the tubules (solid arrow) and the reduction in the number of tubules showing high brush/luminal border enzyme activity. Note increased enzyme activity in the exudents (E). Other tubules show cytoplasmic granular staining.

Fig 3 : 100.0% M. E. - 96 hours - ( A P ) - α napthyl - Fast Garnet GBC. ( 10 x 5 )
Note further reduction in the enzyme activity and reduction in the number of tubule showing brush/luminal border activity (solid arrow). Also note increased cytoplasmic enzyme activity (dashed arrow).

Fig 4 : 100.0% M. E. - 120 hours - ( A P ) - α napthyl - Fast Garnet GBC. ( 20 x 5 )
Note further reduction in the brush/luminal (solid arrow) border enzyme activity and the tubules showing them. Also note the increased cytoplasmic enzyme activity (dashed arrow).
CAPTIONS TO FIGURES

PLATE 55:

Fig 1: Control - Alkaline phosphatase - α napthyl - Fast blue. (20 x 5)
Note the moderate granular staining and staining of the nuclear membrane of the distal tubules (D). Also note the two types of tubules - darkly stained (DT) and lightly stained (arrow).

Fig 2: 0.01% M. E. - 720 hours - Alkaline phosphatase - α napthyl - Fast blue. (20 x 5)
Note slight increase and occurrence of the brush/luminal (dashed arrow) border enzyme activity. Also note increase in the lysosomal granular staining (solid arrow) and absence of enzyme activity in interstitium.

Fig 3: 0.1% M. E. - 24 hours - Alkaline phosphatase - α napthyl - Fast blue. (20 x 5)
Note increase in the enzyme activity of both the types of tubules (solid and dashed arrow). Also note the enzyme activity in glomerulus (G).

Fig 4: 0.1% M. E. - 48 hours - Alkaline phosphatase - α napthyl - Fast blue. (20 x 5)
Note the increased enzyme activity in both the types of tubules (solid and dashed arrow). Also note increased staining of glomerulus (G).
CAPTIONS TO FIGURES

PLATE 56 :

Fig 1 : 0.1% M. E. - 120 hours - Alkaline phosphatase - α napthyl - Fast blue. ( 40 x 5 )
Note further increase in the lysosomal granular staining of both the types of tubules indicating increased enzyme activity (solid and dashed arrow). Also note the enzyme activity in the luminal debris (D).

Fig 2 : 1.0% M. E. - 6 hours - Alkaline phosphatase - α napthyl - Fast blue. ( 20 x 5 )
Note the increased enzyme activity in the glomerulus (G), exudents (E) and the necrotic tubules. Also not increased enzyme activity in collecting tubules (CT).

Fig 3 : 1.0% M. E. - 24 hours - Alkaline phosphatase - α napthyl - Fast blue. ( 40 x 5 )
Note the intense enzyme activity in both the types of tubules (solid and dashed arrow), no staining in the interstitium (I). Also note increased glomerular staining.

Fig 4 : 1.0% M. E. - 72 hours - Alkaline phosphatase - α napthyl - Fast blue. ( 20 x 5 )
Note increase in the granular lysosomal staining of both the types of tubules (solid and dashed arrow). Interstitium without staining (I).
activity but the interstitium was without any enzyme activity (Plate 55 : Fig 3). By the end of fortyeight hours there was further increase in the alkaline phosphatase activity in all the tubules. The glomeruli also showed the increased enzyme activity. In a few 'D' tubules increase in brush/luminal border alkaline phosphatase was observed. The interstitium showed absence of enzyme activity (Plate 55 : Fig 4). At the end of seventytwo hours the renal tubules showed decrease in enzyme activity and then a slight increase in the enzyme activity was noticed at the end of ninetysix hours. Then, by the end of one twenty hours there was further increase in the enzyme activity in both 'D' and 'L' type tubules. The increased activity was exhibited by the increased granular lysosomal staining. The interstitium showed absence of enzyme activity (Plate 56 : Fig 1).

The mallards exposed to 1.0% M.E. promoted increase in the alkaline phosphatase activity at the end of six hours. The glomeruli showed intense lysosomal granular staining along with the 'D' and 'L' type tubules. The collecting tubules also showed increased enzyme activity. The exudents from the interstitium and in the lumina of the tubules showed alkaline phosphatase activity (Plate 56 : Fig 2). By the end of twelve hours the enzyme activity decreased marginally from all the tubules but at the end of twentyfour hours, the alkaline phosphatase activity increased in both the types of tubules, especially 'D' types tubules exhibited intense lysosomal staining. The glomeruli also showed increased enzyme activity but the interstitium showed no enzyme activity. (Plate 56 : Fig 3). Then, at the end of seventytwo hours both the tubules showed intense enzyme activity and the 'D' type tubules showed brush/luminal border alkaline phosphatase along with lysosomal granular enzyme activity. The exudents in the lumen showed enzyme activity. The interstitium did not show enzyme activity (Plate 56 : Fig. 4). By the end of ninetysix hours the alkaline phosphatase activity increased further in both the types of tubules, especially a few 'D' type tubules exhibited very intense
CAPTIONS TO FIGURES

PLATE 57:

Fig 1: 1.0% M. E. - 96 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note further increase in the enzyme activity of both the types of tubules. Also note the increase in glomerular staining (G). Interstitium (I) without enzyme activity.

Fig 2: 5.0% M. E. - 6 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note increased enzyme activity in comparison with the controls. Both the types of tubules show increase in the enzyme activity (solid and dashed arrow). Note the glomerular enzyme activity (G).

Fig 3: 5.0% M. E. - 12 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note intense enzyme activity in both types of tubules (solid and dashed arrow). No staining in interstitium (I).

Fig 4: 5.0% M. E. - 24 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note further increase in the enzyme activity of both the types of tubules. Also note increased enzyme activity in glomerulus (GL). Interstitium (I) without staining, exudents (E) in the interstitium show enzyme activity. The 'D' type tubules show brush/luminal border staining (solid arrow).
enzyme activity and their lumina were filled with the stain. The 'L' type tubules also exhibited increased granular lysosomal staining. The glomeruli showed increased enzyme activity (Plate 57 : Fig 1). The interstitium did not exhibit any enzyme activity. At the end of one twenty hours both the tubules and glomeruli showed further increase in the enzyme activity. The collecting tubules showed marginal increase in the enzyme activity.

Under the influence of 5.0% M.E. the ducks showed a little increase in the alkaline phosphatase activity in the 'D' and 'L' type tubules. A few 'D' type tubules as well as 'L' tubules showed very weak brush/luminal border alkaline phosphatase activity in addition to the granular lysosomal enzyme activity. The interstitium showed absence of enzyme activity while the glomeruli showed granular lysosomal staining (Plate 57 : Fig 2). By the end of twelve hours there was further increase in the alkaline phosphatase activity in all the renal tubules. The debris in the tubule lumina and the interstitial exudents showed the enzyme activity (Plate 57 : Fig 3), and at the end of twentyfour hours there was further increase in the enzyme activity in all the renal tubules especially the 'D' type tubules showed intense enzyme activity at the brush/luminal borders. Though the interstitium showed no enzyme activity, the exudents showed the enzyme activity. The glomeruli showed increased alkaline phosphatase activity (Plate 57 : Fig 4). By the end of fortyeight hours the alkaline phosphatase activity decrease significantly in the renal tubules and subsequently increased a little at the end of seventytwo hours. The glomeruli showed decrease in the enzyme activity and a few 'D' type tubules showed the appearance brush/luminal border enzyme activity (Plate 58 : Fig 1). Then, subsequently at the end of ninetysix and one twenty hours the alkaline phosphatase activity increased gradually in all the tubules.

When the mallards were introduced to 10% M.E. both the 'D' and 'L' type tubules exhibited increase in the enzyme activity. Both the types of tubules showed the appearance of brush/luminal border enzyme activity in few cases.
CAPTIONS TO FIGURES

PLATE 58:

Fig 1: 5.0% M. E. - 72 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note the tubules showing increased cytoplasmic (solid arrow) enzyme activity and the tubules showing increase in the granular (dashed arrow) lysosomal enzyme activity. Also note the staining in glomeruli (GL) and the brush/luminal border enzyme activity (L).

Fig 2: 10.0% M. E. - 6 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note the intense granular staining in the tubules (solid arrow) with luminal border staining. Also note the other types of tubules showing less intense granular staining (dashed arrow) with occasional luminal border enzyme activity. Note the enzyme activity in the debris (D).

Fig 3: 10.0% M. E. - 48 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note the increase in the enzyme activity of all the tubules. Also note the increased staining in the glomerulus (G), enzyme activity in macula densa (M) and in the exudents (E).

Fig 4: 10.0% M. E. - 120 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note slight decrease in the enzyme activity in both the types of tubules (solid and dashed arrows). Note intense staining in glomerulus (G).
CAPTIONS TO FIGURES

PLATE 59:

Fig 1: 50.0% M. E. - 6 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note the intense staining in the necrotic tubules (solid arrow and dashed arrow). Also note widened interstitium (I) without enzyme activity and debris (D) in the lumen shows enzyme activity.

Fig 2: 50.0% M. E. - 12 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note acute increase in the enzyme activity of all the tubules (solid arrow and dashed arrow). Also note the dark brush/luminal border staining in the tubules. Glomerulus (G) with increased enzyme activity. Bowman's capsule (B) and macula densa (M) shows enzyme activity.

Fig 3: 50.0% M. E. - 48 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note increase in the enzyme activity of both the types of tubules especially note the appearance of brush/luminal border enzyme activity (solid and dashed arrow). Note the staining in glomerulus (G). Interstitium (I) is without enzyme activity.

Fig 4: 50.0% M.E./120 h - Alkaline phosphatase - Fast blue. (10 x 5)
Note slight decrease in the enzyme activity of both types of tubules (solid arrow and dashed arrow) in comparison to what is obtained at 48 hours.
The exudents in the lumina of the tubules showed enzyme activity. (Plate 58: Fig 2). By the end of twelve hours the alkaline phosphatase activity increased in all the tubules and then decreased at the end of twentyfour hours. Then at the end of fortyeight hours, there was intense increase in the enzyme activity in all the renal tubules. The macula densa showed intense alkaline phosphatase activity and the exudents in the interstitium showed enzyme activity along with the necrotic glomeruli. In a few cases the Bowman's wall showed membrane alkaline phosphatase activity (Plate 58: Fig 3). Then the enzyme activity went on decreasing at the subsequent time intervals and at the end of one twenty hours, the alkaline phosphatase activity increased a little in all the renal tubules. The glomeruli showed marginal reduction in the enzyme activity. The debris of the necrotic tubules and the walls of Bowman's capsule showed the enzyme activity (Plate 58: Fig 4).

The 50% M.E. promoted sharp increase in the alkaline phosphatase activity at the end of six hours and both the 'D' and 'L' type tubules showed intense enzyme activity. The debris in the lumen of the necrotic tubule showed intense enzyme activity. The interstitium showed absence of enzyme activity (Plate 59: Fig 1). By the end of twelve hours there was a peak increase in the alkaline phosphatase activity in all the renal tubules. A few 'D' and 'L' type tubules showed brush/luminal border enzyme activity. The macula densa showed intense enzyme activity at the luminal border. The necrotic glomeruli showed intense enzyme activity and the distorted wall of Bowman's capsule showed alkaline phosphatase activity. The debris in the lumen of the few tubules showed enzyme activity and the interstitium was without enzyme activity (Plate 59: Fig 2). By the end of twenty four hours there was decline in the enzyme activity from all the tubules but at the end of fortyeight hours there was once again increase in the enzyme activity. The brush and luminal borders of a few tubules showed alkaline phosphatase activity. The interstitium shows no enzyme activity (Plate 59: Fig 3). Then, subsequently the enzyme
CAPTIONS TO FIGURES

PLATE 60:

Fig 1: 100.0% M. E. - 6 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note intense brush/luminal border (solid arrow and dashed arrow) staining in both the types of tubules. Also note glomerular staining (G) and interstitium (I) is without staining.

Fig 2: 100.0% M. E. - 24 hours - Alkaline phosphatase - α naphthyl - Fast blue. (10 x 5)
Note decrease in brush/luminal border staining of both the types of tubules and general increase in the cytoplasmic enzyme activity. Also note slight decrease in the glomerular (G) enzyme activity. Note the staining at the luminal border of macula densa (M).

Fig 3: 100.0% M. E. - 72 hours - Alkaline phosphatase - α naphthyl - Fast blue. (40 x 5)
Note significant reduction in the enzyme activity in necrotic tubules. Two types of tubules could be differentiated on the basis of stainability. Also note the staining in the debris (D) and no staining in interstitium (I).

Fig 4: 100.0% M. E. - 96 hours - Alkaline phosphatase - α naphthyl - Fast blue. (20 x 5)
Note intense increase in the enzyme activity of both the types of tubules. The exudents (E) show enzyme activity and the collecting tubules (CT) show increase in the enzyme activity.
activity declined up to the end of ninetysix hours and at the end of one twenty
hours, there was once again a little increase in the enzyme activity. The
necrotic 'B' type tubules showed brush/luminal border enzyme activity (Plate 59 :
Fig 4).

The ducks exposed to 100% M.E. promoted sharp increase in the
enzyme activity in all the renal tubules, especially the 'D' type tubules showed
intense brush/luminal border enzyme activity. The necrotic glomeruli showed
increase in the enzyme activity. The 'L' type tubules showed increase in the
enzyme activity. The 'L' type tubules showed granular lysosomal enzyme
activity. The interstitium was without enzyme activity (Plate 60 : Fig 1). By the
end of twelve hours there was marginal decline in the enzyme activity in all the
tubules and this decline continued up to the end of twentyfour hours. At the
end of twentyfour hours the alkaline phosphatase activity from the glomeruli
decreased, especially, the brush/luminal border enzyme activity of 'D' type
tubules was abolished but the macula densa showed the luminal border
enzyme activity (Plate 60 : Fig 2). By the end of fortyeight hours, the alkaline
phosphatase activity in all the tubules increased but once again it decreased at
the end of seventy two hours, especially, this decrease was pronounced in a
few 'D' type tubules. Only a few 'D' tubules showed intense enzyme activity.
The 'L' type tubules showed a marginal increase in granular staining. The
interstitium remained unstained (Plate 60 : Fig 3). By the end of ninetysix
hours, there was once again sharp increase in the alkaline phosphatase
activity in all the renal tubules. The 'D' type tubules showed reappearance of
brush/luminal border enzyme activity. The collecting tubules showed increase
in the alkaline phosphatase activity. The exudents in the interstitium exhibited
the enzyme activity. The interstitium was without enzyme activity (Plate 60 :
Fig 4).

Then, by the end of one twenty hours, there was once again decrease in
the alkaline phosphatase activity of all the tubules.
ALTERATIONS IN THE ESTERASE (NONSPECIFIC) ACTIVITY:

Control animals:

The kidney of the control animals showed various staining activities of the nonspecific esterase with the application of different histochemical techniques. But of all the technique tried, the indoxylacetate techniques of Pearson and Grose, 1959 was found most suitable for studying the distribution and localization of the nonspecific esterase activity. It is evident from the histochemical studies in control mallards that there existed two types of renal tubules. The one type, comprised of about sixty percent tubules showing fine granular lysosomal activity and the other comprised of about 40% tubules, without any nonspecific esterase activity. The glomeruli did not exhibit any enzyme activity (Plate 61: Fig 1). Similarly, sixty percent collecting tubules showed very weak lysosomal staining and the remaining forty percent did not show any enzyme activity.

Pathological changes:

The ducks introduced to 0.01% mining effluents (M.E.) did not show any significant alterations in the nonspecific esterase activity up to the end of twenty-nine days, but at the end of thirty days (seven twenty hours) the tubules (proximal and distal) previously showing nonspecific esterase activity showed a little increase in the enzyme activity, while from about 40% remaining tubules, about 2-3% tubules showed a very weak nonspecific esterase activity (Plate 61: Fig 2). By the end of one thousand and eighty hours (45 days), the sixty percent tubules group showed further increase in the enzyme activity and 2-
CAPTIONS TO FIGURES

PLATE 61:

Fig 1: Control - Esterase (Nonspecific) - Indoxyl acetate. (10 x 5)

Note the cytoplasmic esterase activity in some tubules (DT) and also note the other types of tubules (dashed arrow) in the background. The glomerulus (G) shows no staining.

Fig 2: 0.01% M. E. - 720 hours - Esterase (Nonspecific) - Indoxyl acetate. (10 x 5)

Note increase in the cytoplasmic enzyme activity in tubules (DT) and also note the absence of staining (dashed arrow) in other tubules.

Fig 3: 0.1% M. E. - 6 hours - Esterase (Nonspecific) - Indoxyl acetate. (20 x 5)

Note increase in the esterase activity in the tubules (DT) previously showing staining. Also note weak glomerular enzyme activity (G). Note very weak staining in other tubules which previously had no enzyme activity.

Fig 4: 0.1% M. E. - 24 hours - Esterase (Nonspecific) - Indoxyl acetate. (20 x 5)

Note intense staining in few tubules and slightly decreased enzyme activity in few tubules (DT). Also note absence of enzyme activity in glomerulus (G) and other tubules.
CAPTIONS TO FIGURES

PLATE 62:

Fig 1: 0.1% M. E. - 48 hours - Esterase (Nonspecific) - Indoxyl acetate. (10 x 5)
Note slight increase in the esterase activity in the cytoplasm of some tubules (solid arrow). Also note absence of enzyme activity in other tubules (dashed arrow) and collecting tubules (CT).

Fig 2: 0.1% M. E. - 72 hours - Esterase (Nonspecific) - Indoxyl acetate. (20 x 5)
Note slight decrease in the esterase activity of the tubules (solid arrow) previously showing staining and the other tubules show very weak enzyme activity in nuclear membrane. (dashed arrow). Also note membrane esterase of collecting tubules (CT) and weak enzyme activity in glomerulus (G).

Fig 3: 1.0 % M. E. - 6 hours - Esterases (Nonspecific) - Indoxyl acetate.
Note increased enzyme activity in the tubules (solid arrow) and absence of enzyme activity in glomerulus (G) and other tubules (dashed arrow).

Fig 4: 1.0% M. E. - 24 hours - Esterases (Nonspecific) - Indoxyl acetate.
Note slight decrease in the esterase activity of the tubules (DT). Also note absence of enzyme activity in other tubules (dashed arrow), collecting tubules (CT) and glomerulus (G).
3% tubules from the remaining group exhibited further increase in the nonspecific esterase activity.

The ducks subjected to 0.1% M.E. showed significant increase in the nonspecific esterase activity in about sixty percent tubules but interestingly the remaining forty percent tubules showed a very weak esterase (nonspecific) activity, especially about 2 to 3 percent tubules from this group showed a marginally higher activity. The glomeruli and walls of Bowman's capsule exhibited mild staining (Plate 61: Fig 3). By the end of twelve hours there was slight decrease in the nonspecific esterase activity in about sixty percent tubules but at the end of twentyfour hours, there was once again a little increase in the enzyme activity in sixty percent tubules, while rest of the tubules showed loss of nonspecific esterase activity. The glomerular staining was abolished (Plate 61: Fig 4). At the end of forty eight hours the mallards exhibited a slight increase in the non specific esterase activity from the sixty percent tubules while the remaining forty percent did not exhibit any enzyme activity. Similarly, all the collecting tubules did not show any nonspecific esterase activity (Plate 62: Fig 1). By the end of seventytwo hours the mallards exhibited a slight decrease in the enzyme activity from about sixty percent tubules while, the remaining tubules showed a very weak nuclear membrane nonspecific esterase activity. Similarly, all the collecting tubules showed membrane esterase (nonspecific) activities (Plate 62: Fig 2). Then at the end of ninetysix hours there was increase in the enzyme activity in about sixty percent tubules along with the occurrence of a weak enzyme activity in the remaining tubules but once at the end of one twenty hours the esterase (nonspecific) activity decreased from all the tubules.

Under the influence of 1.0% M.E. the ducks showed at the end of six hours a little increase in the nonspecific esterase activity in a little over sixty percent tubules and the activity was fine granular. The remaining tubules as well as glomeruli did not exhibit nonspecific esterase activity. (Plate 62: Fig 3).
CAPTIONS TO FIGURES

PLATE 63:

Fig 1: 1.0% M. E. - 48 hours - Esterase (Nonspecific) - Indoxyl acetate.
(20 x 5)
Note increase in the enzyme activity in the tubules (solid arrow) and no activity in other tubules (dashed arrow).

Fig 2: 1.0% M. E. - 96 hours - Esterase (Nonspecific) - Indoxyl acetate.
(10 x 5)
Note reduction in the enzyme activity in proximal and distal tubules (PT, DT) and absence of activity in the other tubules (dashed arrows) and glomerulus (G).

Fig 3: 5.0% M. E. - 6 hours - Esterase (Nonspecific) - Indoxyl acetate.
(10 x 5)
Note no significant change in the enzyme activity. Few necrotic tubules show luminal border enzyme activity (↑L). Also note absence of esterase activity in other tubules (dashed arrow), glomerulus (G) and collecting tubules (CT).

Fig 4: 5.0% M. E. - 24 hours - Esterase (Nonspecific) - Indoxyl acetate.
(20 x 5)
Note intense staining in the tubules (solid arrow) Necrotic glomeruli (G) show weak enzyme activity.
The collecting tubules did not show enzyme activity. At the end of twelve hours the esterase (nonspecific) activity dropped a little but by the end of twenty four hours the esterase activity decreased in little in comparison to that obtained at the end of six hours. About one percent collecting tubules showed esterase (nonspecific) activity. The glomeruli and other tubules showed absence of enzyme activity (Plate 62 : Fig 4). By the end of fortyeight hours the ducks exhibited sharp increase in the esterase (nonspecific) activity of about sixty percent tubules and occasionally a few tubules from this group showed a weak brush/luminal border activity. The glomeruli and the rest of the tubules did not show enzyme activity (Plate 63 : Fig 1). Then, at the end of seventy two hours the esterase (nonspecific) activity dropped considerably to improve marginally at the end of ninetysix hours but in comparison to that found at the end of fortyeight hours the enzyme activity was low. A little less than sixty percent tubules showed fine granular enzyme activity while the remaining tubules and glomeruli showed absence of esterase (nonspecific) activity (Plate 63 : Fig 2).

The exposure of ducks to 5.0% M.E. induced no significant increase in the nonspecific esterase activity at the end of six hours, in the sixty percent tubules. The glomeruli and the remaining forty percent tubules as well as collecting tubules exhibited absence of enzyme activity (Plate 63 : Fig 3). At the end of twelve hours the nonspecific esterase activity increased marginally but at the end of twentyfour hours the nonspecific esterase activity increased sharply in about sixty percent tubules and the necrotic tubules from this group showed enzyme activity in the luminal debris. The necrotic glomeruli exhibited the occurrence of esterase (nonspecific) activity and in a few cases the wall of Bowman's capsule showed the membrane enzyme activity. About two percent of the tubules from the remaining group showed a weak nuclear membrane esterase (nonspecific) activity, while the rest of the tubules showed absence of enzyme activity (Plate 63 : Fig 4). A few collecting tubules showed weak
CAPTIONS TO FIGURES

PLATE 64:

Fig 1: 5.0% M. E. - 48 hours - Esterase (Nonspecific) - Indoxyl acetate.  
(10 x 5)  
Note a slight decrease in the esterase activity from the tubules (solid arrow) and absence of enzyme activity in other tubules (dashed arrow) and glomerulus (G).

Fig 2: 5.0% M. E. - 120 hours - Esterase (Nonspecific) - Indoxyl acetate.  
(20 x 5)  
Note slight increase in the enzyme activity in a few tubules (solid arrow) while the other tubules (DT) are without enzyme activity (dashed arrow).

Fig 3: 10.0% M. E. - 6 hours - Esterase (Nonspecific) - Indoxyl acetate.  
(20 x 5)  
Note increased enzyme activity in proximal and distal tubules (solid arrow). Also note absence of esterase in other tubules (dashed arrow) except for few necrotic tubules.

Fig 4: 10.0% M. E. - 12 hours - Esterase (Nonspecific) - Indoxyl acetate.  
(10 x 5)  
Note reduced enzyme activity in the proximal and distal tubules (solid arrow) and absence of enzyme activity in other tubules (DT, dashed arrow). Also note the occurrence of membrane esterase in the Bowman's wall (G).
glomeruli and other tubules showed absence of enzyme activity (Plate 66: Fig.3).

Under the influence of 100% M.E. the ducks exhibited increase in the enzyme activity from sixty percent tubules at the end of six hours, while the glomeruli and remaining forty percent tubules as well as collecting tubules showed absence of esterase activity. Then at the end of twelve hours the nonspecific esterase activity reduced sharply and then subsequently increased at the end of twentyfour hours. A few of the tubules showed very intense enzyme activity and about sixty percent tubules showed very intense of nonspecific esterase activity, while the glomeruli and remaining tubules (38%) showed absence of enzyme activity but about two percent tubules showed weak esterase activity (Plate 66 : Fig 4). By the end of fortyeight hours there was no significant change in the nonspecific esterase activity from the tubules. The glomeruli and collecting tubules showed the absence of enzyme activity. Then, at the end of seventytwo hours the sixty percent tubules showed further increase in the enzyme activity, especially a few of the tubules showed intense staining. The glomeruli, about forty percent tubules and collecting tubules showed no enzyme activity (Plate 67 : Fig 1). By the end of ninetysix hours the ducks exhibited sharp increase in the non specific esterase activity, while at the end of one twenty hours there was no further significant increase in the esterase activity but, about sixty percent tubules exhibited intense fine granular lysosomal staining and the luminal debris showed enzyme activity. The remaining tubules did not show esterase activity (Plate 67 : Fig 2). The glomeruli and the collecting tubules showed absense of esterase (nonspecific) activity.
IV] KIDNEY BIOCHEMICAL STUDIES:

It was observed in general, that the mining effluents of different concentrations affected the activities of enzymes such as acid phosphatase, alkaline phosphatase, nonspecific esterase, and concentrations of total proteins, urea, uric acid, creatinine, calcium and chloride ions from the kidney.

1] ACID PHOSPHATASE:

The alterations in the acid phosphatase activities from the kidney of mallards exposed to different concentrations of mining effluents (M.E.) and for the different time intervals are compiled in Table 1 and these alterations are graphically presented in Graph 1 in which variations of the enzyme activity are plotted as a function of different M.E. concentrations and various time intervals. The acid phosphatase activity is expressed as μmole units per gram of wet weight of the tissue.

The control animals’ kidney exhibited acid phosphatase activity equivalent to 205.62 ± 3.892. The animals exposed to 0.01% of M.E. did not exhibit significant changes in the kidney acid phosphatase activity upto 720 hours, but at the end of 720 hours the activity increased to 399.648 ± 5.478 units and went on increasing upto 575.184 ± 9.328 units at the end of 1080 hours.

The 0.1% M.E. induced a progressive increase in the enzyme activity up to the end of 96 hours, while at the end of 120 hours it decreased a little (Graph 1). At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours, the kidney acid phosphatase activity was equivalent to 327.06 ± 9.508, 273.24 ± 9.439, 355.212 ± 8.790, 422.004 ± 7.322, 449.88 ± 5.368, 490.728 ± 5.422 and 454.02 ± 4.968 respectively.
Thus, for all the time intervals the acid phosphatase activity remained above that found in the control animals.

The animals exposed to 1.0% M.E. showed increase in the acid phosphatase activity at the end of six hours but later on exhibited significant fluctuations. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the enzyme activity was equivalent to $364.32 \pm 6.858$, $332.58 \pm 7.948$, $510.6 \pm 4.443$, $487.968 \pm 7.176$, $569.94 \pm 6.348$, $557.52 \pm 7.645$ and $574.08 \pm 8.459$ units respectively.

The 5.0% M.E. induced elevation of the acid phosphatase activity at the end of six hours, but decreased at the end of twelve hours and then showed an increase in the activity which remained steady till the end of fortyeight hours. At the end of seventy two hours the enzyme activity decreased once again and kept on increasing gradually up to the end of one twenty hours. Thus, the acid phosphatase activity was found equivalent to $456.228 \pm 3.753$, $378.948 \pm 5.768$, $524.676 \pm 7.314$, $524.400 \pm 3.891$, $333.132 \pm 4.747$, $558.348 \pm 7.0145$ and $588.432 \pm 7.120$ units at the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one twenty hours respectively.

The mallards exposed to 10.0% M.E. were found to have increased acid phosphatase activity in the kidney at the end of six hours and the enzyme activity went on increasing up to the end of forty eight hours and then the activity gradually decreased through seventytwo and ninetysix hours. But at the end of one twenty hours the acid phosphatase activity increased once again (Graph1). At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours, the kidney acid phosphatase activity was equivalent to $374.532 \pm 7.217$, $387.78 \pm 8.832$, $470.028 \pm 6.789$, $601.956 \pm 6.831$, $528.816 \pm 7.666$, $468.372 \pm 6.904$ and $738.576 \pm 6.072$ units respectively.

On exposure to 50.0% M.E. there was about four fold increase in the kidney acid phosphatase activity at the end of six hours and the activity was
equivalent to 1391.868 ± 12.433 units. The enzyme activity reached to a level of 1609.632 ± 6.348 units at the end of twelve hours and then the enzyme activity kept on decreasing to 1501.992 ± 7.728 and 1290.852 ± 7.010 units for twentyfour and fortyeight hours respectively. Then, once again the enzyme activity steadily increased through seventytwo and ninetysix hours, but it decreased a little at the end of one twenty hours. Thus, the acid phosphatase activity at the end of seventytwo, ninetysix and one twenty hours was equivalent to 1328.802 ± 3.850, 1712.028 ± 8.749 and 1556.088 ± 8.017 units respectively.

The 100.0% M.E. induced maximum increase in the acid phosphatase activity at the end of six hours and was equivalent to 1830.432 ± 8.390 units. At the end of twelve hours the enzyme activity decreased to 1509.306 ± 9.715 units. But from twentyfour to the end of one twenty hours, the enzyme activity went on decreasing and the maximum decrease in the enzyme activity was observed at the end of one twenty hours. However, for all the time intervals under study, the enzyme activity was above that seen in the kidney of control animals. The kidney exhibited acid phosphatase activity equivalent to 1650.204 ± 1.404, 1646.616 ± 6.541, 874.092 ± 4.981, 798.192 ± 7.486 and 586.5 ± 6.168 units respectively.
TABLE NO. 1: THE ALTERATIONS IN THE ACID PHOSPHATASE ACTIVITIES OF THE KIDNEY OF MALLARDS EXPOSED TO MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>205.6±3.892</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td>No significant change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>399.648±5.478</td>
<td>575.184±9.328</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>327.06±9.508</td>
<td>273.24±9.439</td>
<td>355.212±8.790</td>
<td>422.004±7.322</td>
<td>449.88±5.368</td>
<td>490.728±5.422</td>
<td>454.02±4.968</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>1% M.E.</td>
<td>364.32±6.858</td>
<td>332.58±7.948</td>
<td>510.6±4.443</td>
<td>487.968±7.176</td>
<td>569.94±6.348</td>
<td>557.52±7.645</td>
<td>574.08±8.459</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>5% M.E.</td>
<td>456.228±3.753</td>
<td>378.948±5.768</td>
<td>524.676±7.314</td>
<td>524.4±3.891</td>
<td>333.132±4.747</td>
<td>558.348±7.014</td>
<td>588.432±7.120</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>50% M.E.</td>
<td>1391.86±12.433</td>
<td>1609.63±6.348</td>
<td>1501.99±7.728</td>
<td>1290.85±7.010</td>
<td>1328.80±3.850</td>
<td>1712.02±8.749</td>
<td>1556.08±8.017</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>100% M.E.</td>
<td>1830.43±8.390</td>
<td>1509.30±9.7152</td>
<td>1650.20±1.404</td>
<td>1646.61±6.541</td>
<td>874.092±4.981</td>
<td>798.192±7.486</td>
<td>586.5±6.168</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: μmoles/gram wet weight of tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 1: CHANGES IN ACID PHOSPHATASE ACTIVITY OF KIDNEY OF MALLARD EXPOSED TO MINING EFFLUENTS.

Units: μmoles / g wet weight of tissue
2] ALKALINE PHOSPHATASE:

The changes in the alkaline phosphatase activity of the kidney of mallards exposed for various time intervals to the different concentrations of mining effluents, are given in Table 2 and are graphically presented in Graph 2 where the changes in the enzyme activity are presented as a function of various M.E. concentrations and time intervals. The alkaline phosphatase activity is expressed as mmole units per gram wet weight of the tissue.

From Table 2 it is clear that the alkaline phosphatase activity elevated in a concentration dependent manner for the time interval of six hours except for 5.0%, while such a relation could be seen at the time intervals of twelve and twentyfour hours up to 50% M.E. concentration. The animals exposed to 0.01% M.E. did not show any significant change in the kidney alkaline phosphatase activity up to seven twenty hours, but at the end of seven twenty hours it increased slightly, while at the end of one thousand and eighty hours it increased more than one and half fold. The enzyme activity at the end of seven hundred and twenty as well as one thousand and eighty hours was equivalent to 19.75 ± 0.326 and 31.25 ± 0.344 mmole units per gram of wet weight of tissue respectively. Note that the control birds had the enzyme activity equivalent to 15.8 ± 1.317 mmole units only.

The animals exposed to 0.1% M.E. showed a little fluctuation in the enzyme activity. The enzyme activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 18.5 ± 0.326, 16.75 ± 0.401, 17.5 ± 0.256, 19.25 ± 0.531, 17.25 ± 0.574, 20.75 ± 0.444 and 22.5 ± 0.320 mmole units respectively.

The 1.0% M.E. induced slight increase in the enzyme activity, but it fluctuated between 20.25 ± 0.354 mmole units and 35.0 ± 0.431 mmole units. The alkaline phosphatase activity observed at the end of six, twelve,
twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 21.75 ± 0.272, 20.25 ± 0.354, 26.0 ± 0.497, 23.0 ± 0.318, 30.5 ± 0.523, 31.25 ± 0.349 and 35.0 ± 0.431 mmole units respectively.

The birds exposed to 5.0% M.E. exhibited slight increase and fluctuations in the enzyme activity for various time intervals under study. The kidney showed enzyme activity equivalent to 20.75 ± 0.508, 27.0 ± 0.396, 37.5 ± 0.449, 22.5 ± 0.422, 25.25 ± 0.520, 27.0 ± 0.282 and 31.75 ± 0.141 mmole units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The exposure to 10.0% M.E. induced a significant increase in the alkaline phosphatase activity, but the activity fluctuated between 35.0 ± 0.470 mmole units and 85.0 ± 0.449 mmole units. The maximum increase in the activity was observed at the end of fortyeight hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the enzyme activity was equal to 35.0 ± 0.470, 58.0 ± 0.313, 40.25 ± 0.463, 85.0 ± 0.449, 61.5 ± 0.382, 62.5 ± 0.376 and 74.0 ± 0.433 mmole units respectively.

When the mallards were exposed to 50.0% M.E., there was an increase in the enzyme activity in the range of four-fold increase to about ten fold increase in comparison with the enzyme activity seen in the control animals. The maximum increase in the activity was seen at the end of twelve hours. The kidney exhibited alkaline phosphatase activity equivalent to 94.0 ± 0.477, 149.0 ± 0.300, 123.0 ± 0.241, 129.0 ± 0.427, 117.36 ± 0.500, 72.0 ± 0.475 and 100.0 ± 0.515 at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The animals exposed to 100.0% M.E. did not exhibit rise in the enzyme activity to the extent found when exposed to 50.0% M.E. However, it was significantly higher than that found for the exposure to 0.01% to 10.0% mining effluents.
The alkaline phosphatase activity observed at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 98.0 ± 0.477, 97.0 ± 0.578, 70.0 ± 0.621, 91.0 ± 0.372, 34.75 ± 0.470, 95.0 ± 0.326 and 85.0 ± 0.479 mmole units respectively.
TABLE NO. 2: THE ALTERATIONS IN THE ALKALINE PHOSPHATASE ACTIVITY IN THE KIDNEY OF MALLARD EXPOSED TO MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15.8</td>
<td>±1.317</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>18.5</td>
<td>±0.326</td>
<td>16.75</td>
<td>±0.401</td>
<td>17.5</td>
<td>±0.256</td>
<td>19.25</td>
<td>±0.531</td>
<td>17.25</td>
</tr>
<tr>
<td></td>
<td>31.25</td>
<td>±0.3440</td>
<td>31.25</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% M.E.</td>
<td>21.75</td>
<td>±0.272</td>
<td>20.25</td>
<td>±0.354</td>
<td>26.0</td>
<td>±0.497</td>
<td>23.0</td>
<td>±0.318</td>
<td>30.5</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>20.75</td>
<td>±0.508</td>
<td>27.0</td>
<td>±0.396</td>
<td>37.5</td>
<td>±0.449</td>
<td>22.5</td>
<td>±0.422</td>
<td>25.25</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>35.0</td>
<td>±0.470</td>
<td>58.0</td>
<td>±0.313</td>
<td>40.25</td>
<td>±0.463</td>
<td>85.0</td>
<td>±0.449</td>
<td>61.5</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>94.0</td>
<td>±0.477</td>
<td>149.0</td>
<td>±0.300</td>
<td>123.0</td>
<td>±0.241</td>
<td>129.0</td>
<td>±0.427</td>
<td>117.36</td>
</tr>
<tr>
<td>100% M.E.</td>
<td>98.0</td>
<td>±0.477</td>
<td>97.0</td>
<td>±0.578</td>
<td>70.0</td>
<td>±0.621</td>
<td>91.0</td>
<td>±0.372</td>
<td>34.75</td>
</tr>
</tbody>
</table>

Note: Unit: mmoles/gm wet weight of tissue.

N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 2: THE ALTERATIONS IN THE ALKALINE PHOSPHATASE ACTIVITY IN THE KIDNEY OF MALLARD EXPOSED TO MINING EFFLUENTS.

Units: mmoles/gm wet weight of tissue.
ESTERASE (NON SPECIFIC):

The alterations in the esterase (nonspecific) of the kidney of mallard exposed to the mining effluents (M.E.) of different concentrations for various time intervals are tabulated in Table 3, while they are graphically shown in Graph No. 3 wherein they are presented as a function of various concentrations of M.E. over the periods of exposure. From the Table No. 3 it is obvious that animals exposed to the different concentrations of M.E. exhibited wide fluctuations in the enzyme activity and the esterase activity did not show M.E. concentration dependent variations. The control bird showed the nonspecific esterase activity in the kidney to the range of 43.0 ± 0.738 μ mole/units. The animals exposed to 0.01% M.E. did not show any significant change in the enzyme activity upto seven twenty hours but the enzyme activity increased to 53.0 ± 0.422 and 73.5 ± 0.307 units at the end of seven twenty (30 days) and one thousand and eighty hours (45 days) respectively.

The animals exposed to 0.1% M.E. showed increase in the enzyme activity at the end of six hours and was equivalent to 61.5 ± 0.213 units. The enzyme activity fluctuated for various time intervals under study and elevated to 75.0 ± 0.162 units at the end of ninetysix hours. At the end of twelve, twentyfour, fortyeight, seventytwo and one twenty hours the enzyme activity was equivalent to 57.5 ± 0.389, 59.5 ± 0.340, 63.0 ± 0.235, 60.5 ± 0.303 and 66.5 ± 0.389 units respectively.

The 1.0% M.E. induced significant changes in the enzyme activity and it fluctuated between 49.0 ± 0.419 units and 72.5 ± 0.840 units. Interestingly the enzyme activity remained at the same level at the end of twentyfour, ninetysix and one twenty hours. The kidney esterase activity was equivalent to 58.0 ± 0.209, 49.0 ± 0.419, 54.0 ± 0.922, 72.5 ± 0.840, 50.0 ± 0.440, 54.0 ± 0.310 and 54.0 ± 0.344 at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.
The mallards treated with 5.0% M.E. showed increased enzyme activity and the enzyme activity increased progressively from the end of six hours to the end of twentyfour hours and then decreased slightly at the end of fourtyeight hours, but at the end of seventytwo and ninetysix hours the enzyme activity increased progressively. The enzyme activity observed at the end of six, twelve, twentyfour, fourtyeight, seventytwo, ninetysix and one hundred and twenty hours was equivalent to 44.0 ± 0.285, 47.5 ± 0.401, 57.5 ± 0.370, 54.0 ± 0.730, 62.0 ± 0.185, 69.0 ± 0.409 and 62.0 ± 0.253 units respectively.

The 10.0% M.E. induced a minimum increase in the enzyme activity at the end of twentyfour hours and maximum increase in the end of ninetysix hours, while for the rest of the time intervals it fluctuated. At the end of six, twelve, twentyfour, fourtyeight, seventytwo, ninetysix and one twenty hours the esterase activity was equivalent to 63.0 ± 0.354, 56.0 ± 0.363, 45.5 ± 0.457, 59.5 ± 0.340, 66.5 ± 0.320, 78.5 ± 0.318 and 77.0 ± 0.307 units respectively.

When the mallards were exposed to 50.0% M.E. the kidney exhibited very significant increase in the esterase activity. The maximum increase in the enzyme activity was observed at the end of one twenty hours. Generally the enzyme activity remained at or above 60.0 units under the influence of this concentration.

The kidney exhibited enzyme activity equivalent to 61.5 ± 0.215, 63.0 ± 0.392, 60.0 ± 0.248, 80.5 ± 0.185, 70.0 ± 0.422, 78.5 ± 0.365 and 92.5 ± 0.397 units respectively.

Under the influence of 100.0% M.E. the ducks exhibited the fluctuations in the enzyme activity between 45.5 and 92.5 units. The maximum enzyme activity was observed at the end of one twenty hours. The esterase activity observed at the end of six, twelve, twentyfour, fourtyeight, seventytwo, ninetysix and one twenty hours was equivalent to 62.0 ± 0.271, 45.5 ± 0.445, 65.5 ± 0.414, 68.0 ± 0.449, 77.0 ± 0.545, 90.5 ± 0.463 and 92.5 ± 0.278 units respectively.
**TABLE NO. 3 :**  THE ALTERATIONS IN THE ESTERASE (NON SPECIFIC) ACTIVITY OF THE KIDNEY OF MALLARD EXPOSED TO THE MINING EFFLUENTS.

<table>
<thead>
<tr>
<th>Control</th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>±0.738</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0.01% M.E. | 61.5 ±0.213 | 57.5 ±0.389 | 59.5 ±0.340 | 63.0 ±0.235 | 60.5 ±0.303 | 75.0 ±0.162 | 66.5 ±0.389 |            |            |
|            | No significant change |            |            |            |            |            |            |            |            |

| 0.1% M.E. | 58.0 ±0.209 | 49.0 ±0.419 | 54.0 ±0.922 | 72.5 ±0.840 | 50.0 ±0.44 | 54.0 ±0.310 | 54.0 ±0.334 | N.D.       | N.D.       |
| 1% M.E.   | 54.0 ±0.285 | 47.5 ±0.401 | 57.5 ±0.370 | 54.0 ±0.730 | 62.0 ±0.185 | 69.0 ±0.409 | 62.0 ±0.253 | N.D.       | N.D.       |
| 5% M.E.   | 56.0 ±0.354 | 56.0 ±0.363 | 45.5 ±0.457 | 59.5 ±0.340 | 66.5 ±0.32 | 78.5 ±0.318 | 77.0 ±0.307 | N.D.       | N.D.       |
| 10% M.E.  | 63.0 ±0.215 | 63.0 ±0.392 | 60.0 ±0.248 | 80.5 ±0.185 | 70.0 ±0.422 | 78.5 ±0.365 | 92.5 ±0.397 | N.D.       | N.D.       |
| 50% M.E.  | 61.5 ±0.445 | 45.5 ±0.414 | 65.5 ±0.449 | 68.0 ±0.545 | 77.0 ±0.463 | 90.5 ±0.463 | 92.5 ±0.278 | N.D.       | N.D.       |
| 100% M.E. |            |            |            |            |            |            |            | N.D.       | N.D.       |

Note: Unit: μmoles/gram wet weight of tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 3: ALTERATION IN (NON SPECIFIC) ESTERASE OF KIDNEY OF MALLARD EXPOSED TO MINING EFFLUENTS.

Units: μmoles/g wet weight of tissue.
**4] TOTAL PROTEINS:**

The variations in the total protein contents of the kidney of mallards exposed to the various concentrations of mining effluents (M.E.) are compiled in Table No. 4 and are graphically expressed in Graph No. 4 where they are shown as a function of M.E. concentrations over different time intervals. The total proteins are expressed as mg/100 mg of the wet weight of the tissue. The control animals showed the total proteins equal to 29.05 ± 0.371 mg. From the table 4 and graph 4 it is observed that, under the influence of various concentrations of M.E. the kidney protein level progressively decreased in a concentration dependent manner for the time intervals of six, twelve, seventytwo and one twenty hours.

The mallards exposed to 0.01% M.E. showed no significant alterations in the total proteins of the kidney up to seventy-two hours but at the end of seven hundred and twenty as well as one thousand and eighty hours, the kidney protein level decreased a little. Thus, at the end of the above referred hours the protein level was equivalent to 28.372 ± 0.310 and 27.90 ± 1.14 mg respectively.

The 0.1% M.E. induced fluctuations in the protein level from the end of six hours to the end of one hundred and twenty hours. The kidney exhibited the protein concentration equivalent to 27.392 ± 0.216, 26.893 ± 0.116, 28.293 ± 0.132, 27.09 ± 0.185, 25.391 ± 0.24, 24.837 ± 0.24 and 26.03 ± 1.41 mg at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

When the birds were exposed to 1.0% M.E. the protein concentration of the kidney showed significant fluctuations for the time intervals under study. The kidney showed the protein contents equivalent to 25.392 ± 0.11, 24.893 ± 0.101, 25.371 ± 0.21, 23.21 ± 0.116, 22.893 ± 0.31, 20.28 ± 0.22 and 22.08 ±
0.223 mg at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 5.0% M.E. exposure caused progressive decrease in the protein level from the end of six hours to the end of one twenty hours except at the end of fortyeight and ninetysix hours. The protein level at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours were equivalent to 23.789 ± 0.30, 23.0 ± 0.270, 22.342 ± 1.14, 31.87 ± 0.141, 20.32 ± 0.141, 21.27 ± 0.10 and 19.873 ± 0.172 mg respectively.

The birds exposed to 10.0% M.E. showed time dependent decrease in the protein level of the kidney for all the time intervals under study except for ninetysix hours where a marginal increase in the proteins was found. The protein level found at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 22.381 ± 0.1, 22.09 ± 0.172, 20.82 ± 0.15, 19.890 ± 0.141, 17.368 ± 0.146, 17.890 ± 0.141, and 16.482 ± 0.185 mg respectively.

The 50.0% M.E. induced very significant decrease in the kidney protein level but the decrease was not dependent upon the exposure period of the mallards to ME. The kidney protein concentration was equivalent to 20.932 ± 0.185, 21.371 ± 0.215, 16.39 ± 0.149, 14.217 ± 0.16, 15.321 ± 0.132, 13.217 ± 0.14 and 13.813 ± 0.27 mg at the end of six, twelve, twentyfour, fortyeight seventytwo, ninetysix and one twenty hours respectively.

The animals treated with 100.0% M.E. showed maximum reduction in the kidney protein level at the end of one twenty hours, while for the rest of the periods under study it varied between 12.10 and 19.372 mg. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the protein levels was equivalent to 19.372 ± 0.172, 17.21 ± 2.24, 18.37 ± 0.231, 15.32 ± 1.101, 12.10 ± 0.205, 13.37 ± 0.160 and 11.27 ± 0.137 mg respectively.
### TABLE NO. 4 : THE ALTERATIONS IN THE TOTAL KIDNEY PROTEINS OF MALLARDS EXPOSED TO MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>29.05 ±0.371</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td>27.392 ±0.216</td>
<td>26.832 ±0.116</td>
<td>28.293 ±0.132</td>
<td>27.09 ±0.185</td>
<td>25.391 ±0.24</td>
<td>24.837 ±0.24</td>
<td>26.03 ±1.41</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td>25.392 ±0.11</td>
<td>24.893 ±0.101</td>
<td>25.371 ±0.21</td>
<td>23.21 ±0.116</td>
<td>22.893 ±0.31</td>
<td>20.28 ±0.22</td>
<td>22.08 ±0.223</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td>23.789 ±0.30</td>
<td>23.0 ±0.270</td>
<td>22.342 ±1.14</td>
<td>31.87 ±0.141</td>
<td>20.32 ±0.14</td>
<td>21.27 ±0.10</td>
<td>19.873 ±0.172</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td>22.381 ±0.1</td>
<td>22.09 ±0.172</td>
<td>20.82 ±0.15</td>
<td>19.890 ±0.141</td>
<td>17.368 ±0.146</td>
<td>17.890 ±0.141</td>
<td>16.482 ±0.185</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td>20.932 ±0.185</td>
<td>21.371 ±0.215</td>
<td>16.39 ±0.149</td>
<td>14.217 ±0.16</td>
<td>15.321 ±0.132</td>
<td>13.217 ±0.14</td>
<td>13.813 ±0.27</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td>19.372 ±0.172</td>
<td>17.21 ±2.24</td>
<td>18.37 ±1.101</td>
<td>15.32 ±0.205</td>
<td>12.10 ±0.16</td>
<td>13.37 ±0.137</td>
<td>11.27 ±0.137</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

**Note:** Unit: mg of proteins per 100 mg wet weight of tissue.

N.D.: Not Determined.

All alterations are statistically significant - \( P < 0.01 \).
GRAPH NO. 4: KIDNEY - PROTEINS

Units: mg/100mg wet weight of tissue

Hours

mg/100mg

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

Control 6 12 24 48 72 120 720 1080

Legend:
- 0.01% M.E.
- 0.1% M.E.
- 1% M.E.
- 5% M.E.
- 10% M.E.
- 50% M.E.
- 100% M.E.
5] UREA:

The changes in the urea levels of the kidney of ducks exposed to different concentrations of mining effluents at different time intervals are compiled in Table No. 5 and are graphically presented in Graph No. 5 where these changes are given as a function of M.E. concentrations over various time intervals. The control birds showed the urea concentration of kidney equivalent to $1.7 \pm 0.315$ mg per 100 mg of the wet weight of the tissue.

The birds exposed to 0.01% M.E. did not exhibit any significant change in the urea levels till the end of twenty nine days but, at the end of thirtieth day (seven hundred and twenty hours) the kidney exhibited an increase in urea level and the urea level kept on increasing till the end of one thousand and eighty hours. Thus, at the end of seven twenty and one thousand and eighty hours the urea level was equivalent to $6.66 \pm 1.56$ and $9.7 \pm 0.982$ mg respectively.

The mallards exposed to 0.1% M.E. induced increase in the urea level of the kidney from the end of six hours to the end of fortyeight hours, but at the end of seventytwo hours, the urea level decreased a little and then increased at the end of ninety six and one twenty hours. Thus, at the end of six, twelve, twenty four, forty eight, seventy two, ninetysix and one twenty hours, the urea level was equivalent to $4.5 \pm 0.34$, $7.0 \pm 0.872$, $10.0 \pm 0.930$, $11.0 \pm 1.0$, $9.0 \pm 1.01$, $10.3 \pm 1.32$ and $11.7 \pm 1.42$ mg respectively.

The mallards exposed to 1.0% M.E. exhibited steady increase in the urea levels of the kidney from the end of six hours to the end of seventytwo hours but the urea level dropped a little at the end of ninetysix hours and shot up to a high level at the end of one twenty hours. Thus, the kidney urea concentration at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to $6.7 \pm 0.87$, $8.3 \pm 1.01$, $11.3 \pm 1.32$, $13.0 \pm 1.82$, $14.0 \pm 2.3$, $12.3 \pm 0.97$ and $16.0 \pm 2.37$ mg respectively.
When the mallards were exposed to 5.0% M.E. the kidney urea concentrations showed time dependent increase. The urea concentrations went on increasing from the end of six hours to the end of one twenty hours. Thus at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the urea concentrations in the kidney was equivalent to 9.3 ± 0.96, 10.1 ± 0.73, 12.7 ± 2.0, 14.7 ± 1.01, 15.7 ± 1.38, 17.0 ± 2.24 and 19.0 ± 2.1 mg respectively.

The 10.0% M.E. induced fluctuations in the urea levels for the time intervals under study. But the urea levels were quite higher than that found in the control birds. The urea concentrations observed at the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one twenty hours was equivalent to 8.4 ± 0.8, 11.8 ± 0.93, 15.0 ± 0.91, 10.9 ± 2.4, 13.2 ± 1.07, 16.7 ± 1.63 and 15.0 ± 2.0 mg respectively.

The ducks treated with 50.0% M.E. showed a very high increase in the urea level of the kidney and the increase in the urea concentrations exhibited exposure time dependency up to seventy two hours. The urea concentration in the kidney was equivalent to 10.4 ± 13.7, 12.9 ± 2.7, 1.37 ± 1.16, 16.7 ± 2.1, 18.0 ± 1.37, 15.0 ± 1.98 and 10.0 ± 1.34 mg at the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one twenty hours respectively.

The 100.0% M.E. exposure induced time depend rise in the kidney urea levels of the ducks up to the end of fortyeight hours and then the urea level declined at the end of seventytwo hours, but once again it went on increasing steadily up to the end of one twenty hours. The highest concentration of urea was observed at the end of one twenty hours only. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the urea concentrations in the kidney was equivalent to 9.8 ± 2.0, 12.7 ± 1.01, 15.3 ± 1.66, 17.4 ± 2.7, 13.0 ± 1.28, 14.2 ± 2.34 and 19.3 ± 1.72 mg respectively.
<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>1.7</td>
<td>±0.315</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td>4.5</td>
<td>±0.34</td>
<td>7.0</td>
<td>±0.87</td>
<td>10.0</td>
<td>±0.93</td>
<td>11.0</td>
<td>±1.0</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>±0.34</td>
<td></td>
<td>±0.87</td>
<td>±0.93</td>
<td>±1.0</td>
<td>±1.01</td>
<td>±1.32</td>
<td>±1.42</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td>6.7</td>
<td>±0.87</td>
<td>8.3</td>
<td>±1.01</td>
<td>11.3</td>
<td>±1.32</td>
<td>13.0</td>
<td>±2.3</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>±0.87</td>
<td></td>
<td>±1.01</td>
<td></td>
<td>±1.32</td>
<td>±2.3</td>
<td>±0.97</td>
<td>±2.37</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td>9.3</td>
<td>±0.96</td>
<td>10.1</td>
<td>±0.73</td>
<td>12.7</td>
<td>±2.0</td>
<td>14.7</td>
<td>±1.38</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>±0.96</td>
<td></td>
<td>±0.73</td>
<td></td>
<td>±2.0</td>
<td>±1.01</td>
<td>±1.38</td>
<td>±2.24</td>
<td>±2.1</td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td>8.4</td>
<td>±0.8</td>
<td>11.8</td>
<td>±0.93</td>
<td>15.0</td>
<td>±0.91</td>
<td>10.9</td>
<td>±1.07</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td>±0.8</td>
<td></td>
<td>±0.93</td>
<td></td>
<td>±0.91</td>
<td>±2.4</td>
<td>±1.07</td>
<td>±1.63</td>
<td>±2.0</td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td>10.4</td>
<td>±1.37</td>
<td>12.9</td>
<td>±2.7</td>
<td>13.7</td>
<td>±1.16</td>
<td>16.7</td>
<td>±1.37</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>±1.37</td>
<td></td>
<td>±2.7</td>
<td></td>
<td>±1.16</td>
<td>±2.1</td>
<td>±1.37</td>
<td>±1.98</td>
<td>±1.34</td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td>9.8</td>
<td>±2.0</td>
<td>12.7</td>
<td>±1.01</td>
<td>15.3</td>
<td>±1.66</td>
<td>17.4</td>
<td>±2.7</td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>±2.0</td>
<td></td>
<td>±1.01</td>
<td></td>
<td>±1.66</td>
<td>±2.7</td>
<td>±1.28</td>
<td>±2.34</td>
<td>±1.72</td>
</tr>
</tbody>
</table>

**Note:** Unit: mg/100mg wet weight of the tissue.

N.D.: Not Determined.

All alterations are statistically significant - $P < 0.01$. 

GRAPH NO. 5: KIDNEY - UREA
Units: mg/100 mg wet weight of tissue

*mg/100 mg*

- 0.01% M.E.
- 0.1% M.E.
- 1% M.E.
- 5% M.E.
- 10% M.E.
- 50% M.E.
- 100% M.E.

Hours: 0 6 12 24 48 72 96 120 720 1080
6] URIC ACID:

The variations in the uric acid concentrations in the kidney of the mallards exposed to the mining effluents of different concentrations at varying time intervals are compiled in the Table No. 6 and are graphically given in the Graph No. 6 as a function of M.E. concentrations over various exposure periods. The control birds exhibited uric acid concentration equivalent to 2.3 ± 0.21 mg per 100 mg of the wet weight of the tissue. From the graph No. 6, it is clear that the M.E. induced reduction in the uric acid concentration of the kidney at the end of six hours for 0.1, 1.0, 5.0 and 10.0 percent mining effluents.

The birds exposed to 0.01% of M.E. did not exhibit any significant change in the uric acid concentration till the beginning of seven hundred and twenty hours but at the end of seven hundred and twenty hours the uric acid concentration rose to 7.7 ± 0.77 mg and continued to rise further to a level of 13.9 ± 1.01 mg at the end of one thousand and eighty hours.

The 0.1% M.E. induced significant fluctuations in the uric acid concentration. The 0.1% M.E. induced a significant decrease in the uric acid concentration at the end of six, twelve, and twentyfour hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the kidney uric acid concentration was equivalent to 1.5 ± 0.435, 0.9 ± 0.268, 1.2 ± 0.116, 5.7 ± 0.42, 4.6 ± 0.37, 10.1 ± 0.13 and 9.3 ± 0.27 mg respectively.

The mallards exposed to 1.0% M.E. exhibited a significant decrease in the uric acid level at the end of six and twentyfour hours, while the maximum increase in the uric acid concentration was observed at the end of twelve hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the uric acid level of the kidney was
equivalent to 1.7 ± 0.13, 14.6 ± 1.18, 1.4 ± 0.18, 2.8 ± 0.158, 7.7 ± 0.4, 9.91 ± 1.01 and 12.97 ± 1.62 mg respectively.

The 5.0% M.E. induced a very significant decrease in the kidney uric acid concentrations at all the time intervals under study except fortyeight hours. The kidney uric acid concentration at the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one twenty hours was equivalent to 0.9 ± 0.034, 0.9 ± 0.029, 0.7 ± 0.038, 2.4 ± 0.113, 1.3 ± 0.05, 1.0 ± 0.02 and 0.8 ± 0.035 mg respectively.

The mallards exposed to 10.0% M.E. exhibited significant decrease in the uric acid level of the kidney at the end of six, twelve, twentyfour and ninetysix hours, while at the end of fortyeight and one twenty hours it showed over five fold increase in the uric acid concentration. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the kidney uric acid concentration was equivalent to 1.5 ± 0.70, 1.6 ± 0.135, 1.8 ± 0.101, 12.0 ± 1.72, 3.2 ± 0.73, 1.2 ± 0.648 and 11.8 ± 2.2 mg respectively.

The 50.0% M.E. influenced the uric acid level of the kidney and induced significant fluctuations in the uric acid concentration. The uric acid level observed at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours was equivalent to 2.9 ± 0.316, 2.4 ± 0.77, 3.3 ± 0.57, 4.7 ± 0.305, 7.7 ± 0.8, 3.9 ± 0.477 and 5.3 ± 0.39 mg respectively.

Under the influence of 100.0% M.E., the mallards showed a significant increase in the uric acid concentration of the kidney at all the time intervals under study. The uric acid concentration of the kidney was equivalent to 5.7 ± 0.829, 6.9 ± 0.8, 4.9 ± 0.77, 10.37 ± 0.949, 9.8 ± 0.47, 12.0 ± 0.5 and 7.7 ± 1.01 mg at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours respectively.
# Table No. 6: The Changes in the Uric Acid of the Kidney Under the Influence of Mining Effluents

<table>
<thead>
<tr>
<th>Treatment</th>
<th>M.E.</th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.3  ±0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.7 ±0.77</td>
<td>13.9 ±1.01</td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>1.7 ±0.13</td>
<td>14.6 ±1.18</td>
<td>1.4 ±0.18</td>
<td>2.8 ±0.158</td>
<td>7.7 ±0.4</td>
<td>9.91 ±1.01</td>
<td>12.97 ±1.62</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>5% M.E.</td>
<td>0.9 ±0.034</td>
<td>0.9 ±0.029</td>
<td>0.7 ±0.038</td>
<td>2.4 ±0.113</td>
<td>1.3 ±0.05</td>
<td>1.0 ±0.020</td>
<td>0.8 ±0.035</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>10% M.E.</td>
<td>1.5 ±0.70</td>
<td>1.6 ±0.135</td>
<td>1.8 ±0.101</td>
<td>12.0 ±1.72</td>
<td>3.2 ±0.73</td>
<td>1.2 ±0.648</td>
<td>11.8 ±2.2</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>50% M.E.</td>
<td>2.9 ±0.316</td>
<td>2.4 ±0.77</td>
<td>3.3 ±0.57</td>
<td>4.7 ±0.035</td>
<td>7.7 ±0.8</td>
<td>3.9 ±0.477</td>
<td>5.3 ±0.39</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>100% M.E.</td>
<td>5.7 ±0.829</td>
<td>6.9 ±0.8</td>
<td>4.9 ±0.77</td>
<td>10.37 ±0.949</td>
<td>9.8 ±0.47</td>
<td>12.0 ±0.5</td>
<td>7.7 ±1.01</td>
<td>N.D.</td>
<td>N.D.</td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: mg/100mg wet weight of the tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 6:  KIDNEY - URIC ACID.
Units: mg/100 mg wet weight of tissue

mg/100mg

Control  6  12  24  48  72  96  120  720  1080

Hours
The alterations in the creatinine levels of the kidney of mallards exposed to the mining effluents are given in Table No. 7 and are graphically shown in Graph No. 7 where they are presented as the function of concentrations of M.E. over the various time intervals. The creatinine concentrations of the kidney are expressed as mg/100 mg wet weight of the tissue. The control animals showed creatinine level equal to 0.17 ± 0.01 mg. From the table it appears that the mining effluents induced significant fluctuations in the concentrations of creatinine.

The mallards exposed to the 0.01% M.E. did not show any significant change in the creatinine level of the kidney up to seven hundred and twenty hours but, at the end of seven hundred and twenty hours as well as one thousand and eighty hours, the creatinine concentration elevated significantly to 0.345 ± 0.010 and 0.342 ± 0.034 mg respectively in comparison to that found in the control animals.

Under the influence of 0.1% M.E. the creatinine level of the kidney fluctuated between 0.20 mg and 0.501 mg. The maximum elevation in creatinine for this dose was observed at the end of one hundred and twenty hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the kidney creatinine concentration was equivalent to 0.25 ± 0.010, 0.29 ± 0.054, 0.20 ± 0.037, 0.27 ± 0.029, 0.42 ± 0.040, 0.447 ± 0.038 and 0.501 ± 0.049 mg respectively.

The 1.0% M.E. induced acute reduction in the kidney creatinine levels at the end of twentyfour hours. A significantly higher level of creatinine was observed at the end of ninetysix hours. Thus, the kidney creatinine concentration was equivalent to 0.28 ± 0.02, 0.20 ± 0.013, 0.09 ± 0.014, 0.285 ± 0.023, 0.203 ± 0.03, 0.302 ± 0.038 and 0.250 ± 0.04 at the end of six, twelve
twentysix, fortyeight, seventy two, ninetysix and one hundred and twenty hours respectively.

The ducks exposed to 5.0% M.E., exhibited acute increase in creatinine concentration at the end of twelve hours, while for the rest of the time intervals the fluctuations in the creatinine levels were observed. The creatinine concentration of the kidney was equivalent to 0.23 ± 0.05, 0.49 ± 0.034, 0.27 ± 0.038, 0.20 ± 0.013, 0.19 ± 0.054, 0.31 ± 0.08 and 0.27 ± 0.035 mg at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninety six and one twenty hours respectively.

The birds under the influence of 10.0% M.E., showed wide fluctuations in the creatinine levels of the kidney, but the creatinine concentrations were quite above that observed in the control at all the time intervals. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the kidney creatinine concentration was equivalent to 0.5 ± 0.013, 0.45 ± 0.037, 0.30 ± 0.054, 0.355 ± 0.049, 0.27 ± 0.053, 0.29 ± 0.040 and 0.30 ± 0.035 respectively.

The 50.0% M.E. induced reduction in the creatinine concentrations of the kidney at the end of twelve hours, while the maximum increase in creatinine concentration was induced at the end of twentyfour hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the kidney creatinine concentration was equivalent to 0.20 ± 0.05, 0.15 ± 0.016, 0.57 ± 0.060, 0.31 ± 0.038, 0.39 ± 0.040, 0.40 ± 0.035 and 0.31 ± 0.020 respectively.

Under the influence of 100.0% M.E. the ducks exhibited maximum increase in the creatinine concentrations at the end of six hours but the creatinine level decreased at the subsequent time intervals up to the end of twentyfour hours. Then, the creatinine level increased once again at the end of fortyeight hours. After this, the creatinine concentration went on decreasing up to the end of ninetysix hours. The kidney creatinine concentration was
equivalent to 1.1 ± 0.271, 0.80 ± 0.16, 0.73 ± 0.39, 0.96 ± 0.16, 0.83 ± 0.09,
0.34 ± 0.101 and 0.37 ± 0.135 mg at the end of six, twelve, twentyfour, forty
eight, seventytwo, ninetysix and one hundred and twenty hours respectively.
<table>
<thead>
<tr>
<th>Table No. 7: The Changes in the Creatinine Levels of Kidney Under the Influence of Mining Effluents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
</tr>
<tr>
<td>0.01% M.E.</td>
</tr>
<tr>
<td>0.1% M.E.</td>
</tr>
<tr>
<td>1% M.E.</td>
</tr>
<tr>
<td>5% M.E.</td>
</tr>
<tr>
<td>10% M.E.</td>
</tr>
<tr>
<td>50% M.E.</td>
</tr>
<tr>
<td>100% M.E.</td>
</tr>
</tbody>
</table>

Note: Unit: mg/100mg wet weight of tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 7: KIDNEY - CREATININE.
Units: mg/100 mg wet weight of tissue.
CALCIUM:

The alterations in the calcium levels of the kidney of mallards exposed to the various concentrations of mining effluents for different time intervals are tabulated in Table No. 8 and are given graphically in Graph No. 8 where the calcium changes are expressed as the function of concentration of M.E. over the time intervals under study. The calcium concentrations are expressed as mg/100 mg of the wet weight of the tissue. The control animals showed the calcium level equal to 2.1 ± 0.531 mg/100 mg of wet weight of tissue.

From the Table No. 8 it appears that the calcium levels of the kidney exhibited concentration dependent increase for the time intervals of six and twentyfour hours. For the time interval of twelve hours the calcium hike exhibited dose dependency for all the concentrations of M.E. except 10%.

The birds exposed to 0.01% M.E. did not show any significant change in the calcium levels of the kidney up to seven hundred and twenty hours, but at the end of seven hundred and twenty as well as one thousand and eighty hours the kidney exhibited over two fold increase in the calcium levels. Thus, at the end of seven hundred and twenty and one thousand and eighty hours the calcium concentration of the kidney was equivalent to 4.82 ± 0.31 and 5.38 ± 0.185 mg respectively.

The 0.1% M.E. induced marginal increase in the calcium level at the end of six and twelve hours, while the highest increase in calcium level was induced at the end of one hundred and twenty hours. The kidney showed the calcium concentration equivalent to 2.25 ± 0.111, 2.74 ± 0.101, 1.825 ± 0.311, 5.14 ± 0.449, 4.12 ± 0.146, 3.94 ± 0.135 and 8.36 ± 0.215 at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty six hours respectively.
Under the influence of 1.0% M.E. the kidney of ducks exhibited fluctuations in the calcium levels between 4.1mg and 6.08 mg, but in general, the calcium concentration of the kidney was significantly higher than that found in the control animals. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the kidney calcium concentration was equivalent to 4.28 ± 0.584, 5.3 ± 0.141, 4.64 ± 0.215, 4.84 ± 0.30, 4.1 ± 0.14, 5.6 ± 0.260 and 6.08 ± 0.146 mg respectively.

The ducks exposed to 5.0% M.E. showed fluctuations in the calcium concentrations of the kidney, but at the end of six, twelve, and twentyfour hours the kidney showed a gradual increase in the calcium level. The calcium level of the kidney at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours was equivalent to 5.3 ± 0.701, 6.52 ± 0.56, 6.58 ± 0.278, 4.82 ± 0.324, 8.7 ± 0.22, 6.02 ± 0.483 and 6.4 ± 0.303 mg respectively.

The 10.0% M.E. induced fluctuations in the calcium level of the kidney and the calcium level was higher for all the time intervals under study when compared with that of control. The calcium level appeared to increase gradually from the end of six hours to the end of twentyfour hours. The maximum increase in the calcium was observed at the end of ninetysix hours. The calcium level of the kidney at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours was equivalent to 5.72 ± 0.342, 6.20 ± 0.141, 7.34 ± 0.307, 6.08 ± 0.248, 7.52 ± 0.172, 15.14 ± 0.167 and 6.72 ± 0.278 mg respectively.

The mallards exposed to 50.0% M.E. exhibited a significant increase in the calcium level of the kidney, but the calcium level was fluctuating between 6.62 to 11.62 mg. The maximum increase in the calcium level was observed at the end of six hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours, the kidney calcium level was
equivalent to 11.62 ± 0.172, 10.22 ± 0.248, 10.48 ± 0.285, 9.34 ± 0.257, 6.62 ± 0.248, 8.34 ± 0.241 and 6.86 ± 0.101 mg respectively.

The 100.0% M.E. induced the highest elevation of calcium level at the end of six hours but afterwards the calcium level exhibited wide fluctuations. The calcium concentration of the kidney was equivalent to 21.8 ± 0.493, 18.02 ± 0.177, 20.1 ± 0.532, 3.82 ± 0.146, 4.44 ± 0.344, 6.34 ± 0.205 and 9.42 ± 0.172 mg at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours respectively.
<table>
<thead>
<tr>
<th>TABLE NO. 8 : THE CHANGES IN THE CALCIUM LEVELS IN KIDNEY UNDER THE INFLUENCE OF MINING EFFLUENTS.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>0.01% M.E.</td>
</tr>
<tr>
<td>0.1% M.E.</td>
</tr>
<tr>
<td>1% M.E.</td>
</tr>
<tr>
<td>5% M.E.</td>
</tr>
<tr>
<td>10% M.E.</td>
</tr>
<tr>
<td>50% M.E.</td>
</tr>
<tr>
<td>100% M.E.</td>
</tr>
</tbody>
</table>

Note: Unit: mg/100mg wet weight of the tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 8: KIDNEY - CALCIUM
Units: mg/100 mg wet weight of tissue

- Control
- 6 hours
- 12 hours
- 24 hours
- 48 hours
- 72 hours
- 120 hours
- 720 hours
- 1080 hours

[Bar graph showing calcium levels at different M.E. concentrations over time]
The changes in the chloride contents of the kidney of mallards exposed to the various concentrations of the mining effluents at different time intervals are compiled in Table No. 9 and are shown graphically in Graph No. 9 where the changes in the chloride contents are given as a function of concentrations of mining effluents over the different time intervals. The chloride contents are expressed as milliequivalence per 100 mg of the wet weight of the tissue. The control animals showed the chloride contents equivalent to 20.0 ± 1.7 mg /100 mg of the wet weight of the tissue. From the table it appears that the 50.0% and 100.0% M.E. induced over four fold increase in the kidney chloride contents, except a few time intervals.

The birds exposed to 0.01% M.E. did not show any change in the chloride contents up to seven twenty hours, but at the end of seven twenty and one thousand and eighty hours the kidney chlorides raised to 29.3 ± 0.949 and 38.74 ± 1.10 mEq respectively.

The 0.1% M.E. induced significant reductions in the chloride contents but at all the time intervals except six hours. The chloride contents remained below the level found in the control animals. The chloride contents found in the kidney were equivalent to 22.8 ± 2.22, 8.375 ± 0.39, 17.36 ± 0.77, 18.4 ± 0.477, 18.62 ± 0.503, 15.06 ± 0.574 and 14.12 ± 0.305 mEq at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours respectively.

When the ducks were exposed to 1.0% M.E., the kidney exhibited decrease in chloride contents at all the time intervals under study except at the end of ninetysix hours. The chloride contents of the kidney at the end of six twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours were
equivalent to 17.6 ± 0.316, 16.22 ± 0.416, 17.74 ± 0.241, 7.76 ± 0.69, 5.36 ± 0.349, 41.50 ± 1.0 and 16.3 ± 2.9 mEqs respectively.

The 5.0% M.E. induced increase in the concentrations of chlorides over that found in the controls, but the chloride values fluctuated between 24.0 and 57.0 mEqs. The chloride contents of the kidney were equivalent to 30.0 ± 1.8, 24.0 ± 0.05, 49.0 ± 1.36, 38.0 ± 2.6, 43.0 ± 1.01, 57.0 ± 2.2 and 37.0 ± 1.09 at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The animals exposed to 10.0% M.E. showed decrease in the chloride contents at the end of six hours, while the highest concentration was shown at the end of ninetysix hours. The chloride contents fluctuated between 17.0 mEqs and 53 mEqs. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the chloride contents of the kidney were equivalent to 17.0 ± 1.72, 26.0 ± 0.4, 33.0 ± 0.7, 32.0 ± 1.0, 33.0 ± 0.57, 53.0 ± 2.56 and 37.0 ± 1.4 mEqs respectively.

On exposure to 50.0% M.E. the birds exhibited a remarkable increase in the kidney chloride contents. The chloride contents showed a gradual increase from the end of six hours to the end of twenty four hours. The kidney exhibited chloride contents equivalent to 87.8 ± 1.326, 88.5 ± 0.5, 89:8 ± 1.3, 85.8 ± 1.72, 89.1 ± 1.341, 44.43 ± 0.79 and 42.5 ± 1.239 mEqs at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 100.0% M.E. induced the peak increase in the chloride contents of the kidney at the end of seventytwo hours and the chloride contents fluctuated between 66.6 and 535.0 mEqs. At the end of six twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the kidney showed chloride contents equivalent to 89.2 ± 1.16, 84.75 ± 0.829, 88.4 ± 1.019, 88.6 ± 0.8, 535 ± 3.86, 66.6 ± 1.85 and 106.6 ± 3.92 mEqs respectively.
<table>
<thead>
<tr>
<th>Hour</th>
<th>Control</th>
<th>0.01% M.E.</th>
<th>0.1% M.E.</th>
<th>1% M.E.</th>
<th>5% M.E.</th>
<th>10% M.E.</th>
<th>50% M.E.</th>
<th>100% M.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>20.0 ±1.7</td>
<td>22.8 ±2.22</td>
<td>22.8 ±0.32</td>
<td>17.6 ±0.32</td>
<td>30.0 ±1.8</td>
<td>17.0 ±1.72</td>
<td>87.8 ±1.326</td>
<td>89.2 ±1.16</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>8.375 ±0.39</td>
<td>16.22 ±0.416</td>
<td>16.22 ±0.416</td>
<td>24.0 ±0.5</td>
<td>26.0 ±0.4</td>
<td>88.5 ±0.5</td>
<td>84.75 ±0.829</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>17.36 ±0.77</td>
<td>17.74 ±0.241</td>
<td>17.74 ±0.241</td>
<td>49.0 ±1.36</td>
<td>33.0 ±0.7</td>
<td>89.8 ±1.3</td>
<td>88.4 ±1.019</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>18.4 ±0.477</td>
<td>7.76 ±0.69</td>
<td>7.76 ±0.69</td>
<td>38.0 ±2.6</td>
<td>32.0 ±1.0</td>
<td>85.8 ±1.72</td>
<td>88.6 ±0.829</td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>18.62 ±0.503</td>
<td>5.36 ±0.349</td>
<td>5.36 ±0.349</td>
<td>43.0 ±1.01</td>
<td>33.0 ±1.0</td>
<td>89.1 ±1.341</td>
<td>535.0 ±1.019</td>
</tr>
<tr>
<td>96</td>
<td></td>
<td>15.06 ±0.574</td>
<td>41.50 ±1.0</td>
<td>41.50 ±1.0</td>
<td>57.0 ±2.2</td>
<td>30.0 ±1.0</td>
<td>44.43 ±1.341</td>
<td>66.6 ±0.8</td>
</tr>
<tr>
<td>120</td>
<td></td>
<td>14.12 ±0.305</td>
<td>16.3 ±2.9</td>
<td>16.3 ±2.9</td>
<td>37.0 ±1.09</td>
<td>37.0 ±2.56</td>
<td>42.5 ±1.239</td>
<td>106.6 ±3.92</td>
</tr>
<tr>
<td>720</td>
<td></td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1080</td>
<td></td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Note: Unit: mEq/100mg wet weight of the tissue.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 9: KIDNEY - CHLORIDE

Units: mEq/100mg of wet weight tissue.
CHAPTER III

SECTION - B

URINE
A] ACID PHOSPHATASE:

The changes in the renal clearance of acid phosphatase (AP) of the ducks exposed to the different concentrations of mining effluents at different time intervals are compiled in Table No. 10 and are graphically given in Graph No. 10. The activities of the acid phosphatase were calculated on the basis of p-nitrophenol unit (μmol) per hundred millilitres of urine. The control animals did not show any acid phosphatase activity in the urine indicating no renal clearance of the acid phosphatase.

From the table it appears that only at the end of ninetysix hours there was concentration dependent rise in the renal clearance of the acid phosphatase for all concentrations under study, while for the time intervals of twelve and forty eight hours the concentration dependent increase in the renal clearances of AP was observed for 0.1, 1.0, 5.0, 10.0, and 50.0 M.E. The highest AP activity in the urine was found at the end of fortyeight hours under the influence of 50.0% M.E.

The birds exposed to 0.01% M.E. did not show any AP activity in the urine up to seven hundred and twenty hours, but at the end of seven twenty and one thousand and eighty hours the enzyme activity was equivalent to 57.408 ± 5.202 and 142.416 ± 7.314 was observed.

The 0.1% M.E. induced progressive renal clearance of AP for all the time intervals under study except twentyfour hours. The AP activity in the urine at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 81.42 ± 6.19, 95.496 ± 6.553, 93.288 ± 6.624, 103.224 ± 3.941, 137.724 ± 5.671, 144.348 ± 5.823 and 168.912 ± 6.499 units respectively.

The birds exposed to 1.0% M.E. showed progressive increase in the renal clearance of AP for all the time intervals under study, except seventy two
hours and one twenty hours, as depicted by the increase in the urinary AP activity. The urinary AP activity was equivalent to 108.744 ± 6.003, 118.404 ± 6.941, 135.792 ± 8.252, 139.104 ± 4.890, 127.65 ± 5.299, 160.356 ± 6.669 and 146.832 ± 8.528 units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours.

Under the influence of 5.0% M.E. the mallards exhibited progressive increase in the renal clearance of AP, as seen by the increased AP activity in the urine, for all the time intervals except fortyeight hours. The urinary AP activity was equivalent to 139.38 ± 5.423, 175.26 ± 5.299, 192.096 ± 6.430, 185.472 ± 7.383, 214.452 ± 6.196, 235.704 ± 9.211 and 253.092 ± 7.383 units respectively.

The ducks exposed to 10.0% M.E. showed progressive increase in the renal clearance of AP up to the end of seventytwo hours only. The urinary AP activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 176.088 ± 5.796, 209.208 ± 7.866, 231.564 ± 5.878, 264.564 ± 8.142, 302.772 ± 8.790, 280.692 ± 6.207 and 302.772 ± 8.293 units respectively.

The exposure to 50.0% M.E. induced wide fluctuations in the renal clearance of AP but the highest renal clearance of AP was induced at the end of fortyeight hours. The urinary AP activity was equivalent to 167.256 ± 9.850, 332.856 ± 7.111, 137.448 ± 3.750, 651.084 ± 6.948, 369.84 ± 5.789, 533.508 ± 7.014 and 560.28 ± 9.066 units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 100.0% M.E. induced progressive renal clearance of AP up to the end of fortyeight hours, but at later hours it fluctuated significantly. The urinary AP activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 94.392 ± 4.747, 129.444 ± 4.885, 367.90 ± 5.827, 518.604 ± 6.486, 183.54 ± 5.351, 558.624 ± 7.424 and 282.9 ± 6.679 units respectively.
TABLE NO. 10: THE CHANGES IN THE URINE ACID PHOSPHATASES UNDER THE INFLUENCE OF MINING EFFLUENTS

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.00</td>
<td>±0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td>81.42</td>
<td>95.496</td>
<td>93.288</td>
<td>103.224</td>
<td>137.724</td>
<td>144.348</td>
<td>168.912</td>
<td>57.408</td>
<td>142.416</td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>108.744</td>
<td>118.404</td>
<td>135.792</td>
<td>139.104</td>
<td>127.65</td>
<td>160.356</td>
<td>146.832</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>139.38</td>
<td>175.26</td>
<td>192.096</td>
<td>185.472</td>
<td>214.452</td>
<td>235.704</td>
<td>253.092</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>176.088</td>
<td>209.208</td>
<td>231.564</td>
<td>264.564</td>
<td>302.772</td>
<td>280.692</td>
<td>302.772</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±5.796</td>
<td>±7.866</td>
<td>±5.878</td>
<td>±8.142</td>
<td>±8.790</td>
<td>±6.207</td>
<td>±8.293</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10% M.E.</td>
<td>167.256</td>
<td>332.856</td>
<td>137.448</td>
<td>651.084</td>
<td>369.84</td>
<td>533.508</td>
<td>560.28</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>94.392</td>
<td>129.444</td>
<td>367.90</td>
<td>518.604</td>
<td>183.54</td>
<td>558.624</td>
<td>282.9</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>100% M.E.</td>
<td>94.392</td>
<td>129.444</td>
<td>367.90</td>
<td>518.604</td>
<td>183.54</td>
<td>558.624</td>
<td>282.9</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Note: Unit: p-nitropholin μmoles/100 ml.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 10: URINE - ACID PHOSPHATASE
Units: µmoles/100 ml.
B] ALKALINE PHOSPHATASE:

The renal clearances of alkaline phosphatase (AIP) are tabulated in Table No. 11 and are given graphically in Graph No. 11. The control animals did not show any AIP activity in the urine. The alkaline phosphatase activity is expressed as mmole units per 100 ml of urine. From the graph it is observed that the dose (concentration of M.E.) dependent increase in the renal clearance of AIP was induced in the ducks at the end of twelve and ninetysix hours, while such a relationship was observed at the end of twelve and one twenty hours for 0.1, 1.0, 5.0, 10.0 and 50.0 percent concentrations of M.E.

The birds exposed to 0.01% M.E. did not show any AIP activity in the urine up to twentynine days, but at the end of thirty days (seven hundred and twenty hours) the urine showed the AIP activity equivalent to 0.4 ± 0.053 and at the end of one thousand and eighty hours the urinary AIP activity was equivalent to 0.85 ± 0.062 mmole units.

The 0.1% M.E. induced progressive renal clearance of AIP for all the time intervals under study except twentyfour hours. The AIP urinary activity was equivalent to 0.5 ± 0.040, 0.7 ± 0.034, 0.6 ± 0.04, 0.8 ± 0.048, 0.95 ± 0.066, 1.1 ± 0.082 and 1.3 ± 0.071 units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours respectively.

On exposure to 1.0 % M.E. the birds showed progressive urinary clearance of AIP for all the time intervals under study except forty eight hours and in general the renal clearance of AIP was higher than that induced by 0.1% M.E. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the urinary AIP activity was equivalent to 0.75 ± 0.049, 1.0 ± 0.034, 1.15 ± 0.046, 0.95 ± 0.051, 1.3 ± 0.054, 1.45 ± 0.064 and 1.65 ± 0.020 mmole units respectively.
The 5.0% M.E. induced significant increase and fluctuations in the renal clearance of AIP. The urinary AIP activity was equivalent to 1.4 ± 0.064, 1.35 ± 0.166, 1.20 ± 0.034, 1.75 ± 0.063, 1.45 ± 0.079, 1.85 ± 0.046 and 2.85 ± 0.112 mmole units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The ducks exposed to 10.0% M.E. exhibited fluctuations in the renal clearance of AIP and the maximum renal clearance was seen at the end of one twenty hours. The urinary AIP activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 1.35 ± 0.04, 1.40 ± 0.068, 1.85 ± 0.091, 2.10 ± 0.129, 2.90 ± 0.092, 3.10 ± 0.092 and 5.80 ± 0.094 mmole units respectively.

Under the influence of 50.0% M.E. the ducks exhibited highest renal clearance of AIP at the end of one twenty hours, while at the other time intervals there were fluctuations in the renal clearances. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 1.50 ± 0.068, 3.50 ± 0.109, 1.30 ± 0.652, 5.10 ± 0.052, 1.30 ± 0.131, 4.15 ± 0.078 and 13.60 ± 0.066 mmole units respectively.

The 100.0% M.E. exposure of ducks induced fluctuations in the renal clearance of AIP. The urinary AIP activity was equivalent to 5.40 ± 0.119, 3.50 ± 0.085, 4.90 ± 0.123, 10.80 ± 0.091, 2.85 ± 0.120, 4.30 ± 0.149 and 2.40 ± 0.052 mmole units at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.
### Table No. 11: The Effect of Mining Effluents on Urine Alkaline Phosphotases.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>0.00 ± 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No significant change</td>
<td></td>
<td></td>
<td>0.4 ± 0.053</td>
<td>0.85 ± 0.0624</td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td>0.50 ± 0.04</td>
<td>0.70 ± 0.034</td>
<td>0.60 ± 0.04</td>
<td>0.80 ± 0.048</td>
<td>0.95 ± 0.066</td>
<td>1.10 ± 0.082</td>
<td>1.30 ± 0.071</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td>0.75 ± 0.049</td>
<td>1.0 ± 0.034</td>
<td>1.15 ± 0.046</td>
<td>0.95 ± 0.051</td>
<td>1.30 ± 0.054</td>
<td>1.45 ± 0.064</td>
<td>1.65 ± 0.020</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td>1.40 ± 0.064</td>
<td>1.35 ± 0.166</td>
<td>1.20 ± 0.034</td>
<td>1.75 ± 0.063</td>
<td>1.45 ± 0.079</td>
<td>1.85 ± 0.046</td>
<td>2.85 ± 0.112</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td>1.35 ± 0.04</td>
<td>1.40 ± 0.068</td>
<td>1.85 ± 0.091</td>
<td>2.10 ± 0.129</td>
<td>2.9 ± 0.092</td>
<td>3.10 ± 0.092</td>
<td>5.80 ± 0.094</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td>1.50 ± 0.068</td>
<td>3.50 ± 0.109</td>
<td>1.30 ± 0.652</td>
<td>5.10 ± 0.052</td>
<td>1.30 ± 0.131</td>
<td>4.15 ± 0.078</td>
<td>13.6 ± 0.066</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td>5.40 ± 0.119</td>
<td>3.50 ± 0.085</td>
<td>4.90 ± 0.123</td>
<td>10.80 ± 0.091</td>
<td>2.85 ± 0.120</td>
<td>4.30 ± 0.149</td>
<td>2.40 ± 0.052</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

**Note:** Unit: mmoles/100 ml.

**N.D.:** Not Determined.

All alterations are statistically significant - \( P < 0.01 \).
GRAPH NO. 11: URINE - ALKALINE PHOSPHATASE
Units: mmoles/100 ml.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Control</th>
<th>6</th>
<th>12</th>
<th>24</th>
<th>48</th>
<th>72</th>
<th>96</th>
<th>120</th>
<th>720</th>
<th>1080</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C] ESTERASE (NON SPECIFIC):

The changes in the urine Esterase (nonspecific) activities are compiled in Table No. 12 and are graphically given in Graph No. 12. The Esterase (nonspecific) activity is expressed as µmoles per hundred millilitre of urine. The control birds did not show any renal clearance of Esterase.

From the graph it appears that the urinary excretion of Esterase was dose dependent (M.E. concentration dependent) at the end of twelve, twentyfour, and fortyeight hours. The highest urinary esterase activity was observed at the end of twelve hours under the influence of 100% M.E. and generally all the M.E. concentrations induced increased urinary Esterase activity.

The birds exposed to 0.01% M.E. did not show any Esterase activity up to twentynine days but at the end of thirty days (Seventwenty hours) the urinary Esterase activity was equivalent to 100.0 ± 3.098 µmoles and it shot up to 165.0 ± 3.929 µmoles at the end of one thousand and eighty hours.

The 0.1% M.E. induced progressive increase in the urinary Esterase activity for all the time intervals under study except ninetysix hours. The Esterase activity was equivalent to 205.0 ± 2.059, 270.0 ± 3.611, 315.0 ± 3.059, 345.0 ± 2.059, 370.0 ± 5.851, 315.0 ± 3.261, and 425.0 ± 3.847 units (µmoles) at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours respectively.

The mallards exposed to 1.0% M.E. exhibited increased urinary Esterase activity indicating increased renal clearance of the enzyme. The urinary enzyme activity showed significant fluctuations and the maximum activity was observed at the end of one twenty hours. The urinary esterase activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty
hours was equivalent to 585.0 ± 3.929, 490.0 ± 2.828, 470.0 ± 2.154, 445.0 ± 3.762, 530.0 ± 7.054, 575.0 ± 3.059 and 620.0 ± 3.006 μmoles respectively.

Under the influence of 5.0% M.E. the ducks showed some fluctuations in the esterase activity but the enzyme activity did not increase much in comparison to the increase observed under the influence of 1.0% M.E. The Esterase activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 510.0 ± 2.653, 510.0 ± 2.15, 485.0 ± 3.611, 530.0 ± 2.497, 530.0 ± 5.215, 615.0 ± 6.829 and 645.0 ± 3.249 μmoles respectively.

The 10.0% M.E. exposure induced rise in the urinary esterase activity but the rise was not dependent upon the exposure duration. Thus, the urinary Esterase activity was equivalent to 575.0 ± 4.578, 600.0 ± 3.544, 510.0 ± 4.923, 630.0 ± 5.810, 645 ± 5.381, 585.0 ± 5.381 and 700.0 ± 4.223 μmoles at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The exposure to 50.0% M.E. induced further increase in the urinary esterase activity and the maximum activity was found at the end of ninetysix hours. The urinary esterase activity at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 760.0 ± 4.40, 680.0 ± 2.856, 560.0 ± 1.720, 750.0 ± 1.93, 700.0 ± 3.898, 800.0 ± 2.712 and 750.0 ± 2.856 μmoles respectively.

The ducks exposed to 100.0% M.E. showed many fold increase in the urinary esterase activity. The highest increase in the enzyme activity was observed at the end of twelve hours but the activity decreased very significantly at the end of ninetysix hours. The urinary esterase activity was equivalent to 960.0 ± 3.633, 1560.0 ± 3.006, 680.0 ± 4.45, 1020.0 ± 2.416, 595.0 ± 1.720, 210.0 ± 2.315 and 405.0 ± 5.706 μmoles at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours respectively.
TABLE 12: THE EFFECT OF MINING EFFLUENTS ON URINE ESTERASES (NONSPECIFIC)

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.00</td>
<td>± 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>205</td>
<td>± 2.059</td>
<td>270</td>
<td>± 3.611</td>
<td>315</td>
<td>± 3.059</td>
<td>345</td>
<td>± 2.059</td>
<td>370</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>585</td>
<td>± 3.929</td>
<td>490</td>
<td>± 2.828</td>
<td>470</td>
<td>± 2.154</td>
<td>445</td>
<td>± 3.762</td>
<td>530</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>510</td>
<td>± 2.653</td>
<td>510</td>
<td>± 2.15</td>
<td>485</td>
<td>± 3.611</td>
<td>530</td>
<td>± 2.497</td>
<td>530</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>575</td>
<td>± 4.578</td>
<td>600</td>
<td>± 3.544</td>
<td>510</td>
<td>± 4.923</td>
<td>630</td>
<td>± 5.810</td>
<td>645</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>760</td>
<td>± 4.4</td>
<td>680</td>
<td>± 2.856</td>
<td>560</td>
<td>± 1.720</td>
<td>750</td>
<td>± 1.93</td>
<td>700</td>
</tr>
<tr>
<td>100% M.E.</td>
<td>960</td>
<td>± 3.633</td>
<td>1560</td>
<td>± 3.006</td>
<td>680</td>
<td>± 4.45</td>
<td>1020</td>
<td>± 2.416</td>
<td>595</td>
</tr>
</tbody>
</table>

Note: Unit: μmoles/100 ml.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 12: URINE - ESTERASE (NON SPECIFIC)

Units: μmoles/100 ml.

- Graph showing the concentration of esterase in urine over time.
- Y-axis: moles/100ml, ranging from 0 to 1600.
- X-axis: Hours, ranging from Control to 1080.
- Different concentrations are indicated by various symbols.
- Data points are shown for specific time intervals (6, 12, 24, 48, 72, 96, 120, 720, 1080 hours).

The graph indicates changes in esterase levels over time at different concentrations.
D) PROTEINS:

The Table No. 13 shows the variations in the protein contents of the urine of mallards exposed to the different concentrations of the mining effluents for various time intervals and the same is graphically given in Graph No.13. The proteins from the urine are expressed as gram per litre of the urine. The urine of the control animals did not show any proteins. From the table it is obvious that the birds under the influence of mining effluents promoted the renal clearance of proteins but renal clearance of proteins was neither dose nor time dependent.

The 0.01% M.E. did not induce renal clearance of proteins upto twenty nine days exposure, but at the end of thirty days (seven twenty hours) the renal clearance was equivalent to $3.30 \pm 0.13$ g/L and it elevated to $4.6 \pm 0.21$ g/L at the end of one thousand and eighty hours.

The animals exposed to 0.1% M.E. showed fluctuations in the renal clearance of proteins and the urine exhibited decrease in proteins clearance than that observed under the influence of 0.01% M.E. The urine proteins at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninety six, and one twenty hours amounted to $2.68 \pm 0.116$, $2.96 \pm 0.101$, $2.94 \pm 0.10$, $2.48 \pm 0.172$, $2.82 \pm 0.14$, $2.96 \pm 0.101$ and $2.70 \pm 0.228$ grams per litre respectively.

Under the influence of 1.0% M.E. the renal clearance of proteins fluctuated between $2.16$ g and $3.72$ g per litre of urine. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninety six and one twenty hours the renal clearance of the proteins was equivalent to $3.175 \pm 0.147$, $2.16 \pm 0.101$, $3.72 \pm 0.213$, $2.64 \pm 0.215$, $2.38 \pm 0.23$, $3.38 \pm 0.172$ and $3.64 \pm 0.30$ grams per litre respectively.

The ducks exposed to 5.0% M.E. showed the renal clearance of proteins less than 3.4 g. The urine showed presence of $2.70 \pm 0.244$, $2.48 \pm 0.16$, $2.32$
± 0.172, 2.40 ± 0.178, 2.46 ± 0.185, 3.40 ± 0.282 and 2.54 ± 0.162 grams of proteins per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

Under the influence of 10.0% M.E. the renal clearance of proteins varied between 2.54 g and 2.74 grams. The urine showed the presence of 2.68 ± 0.17, 2.68 ± 0.130, 2.74 ± 0.135, 2.54 ± 0.257, 2.62 ± 0.172, 2.72 ± 0.16 and 2.56 ± 0.215 grams of proteins per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours respectively.

The 50.0% M.E. treatment to the ducks promoted increase in the renal clearance of proteins. The maximum clearance was observed at the end of ninetysix hours, while minimum clearance was seen at the end of twentyfour hours. Thus, the renal clearance of proteins amounted to 3.22 ± 0.172, 3.96 ± 0.101, 2.96 ± 0.101, 4.16 ± 0.185, 3.2 ± 0.14, 4.28 ± 0.172 and 3.6 ± 0.129 grams per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 100.0% M.E. induced significant fluctuations in the protein contents of the urine and the highest quantity was observed at the end of twentyfour hours. The urine protein level was equivalent to 3.20 ± 0.228, 3.54 ± 0.21, 4.46 ± 0.162, 3.94 ± 0.101, 3.98 ± 0.172, 2.36 ± 1.132 and 2.41 ± 0.100 grams per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.
TABLE NO. 13 : URINE PROTEIN LEVELS UNDER THE INFLUENCE OF MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.30 ±0.13</td>
<td>4.60 ±0.21</td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>2.68 ±0.116</td>
<td>2.96 ±0.101</td>
<td>2.94 ±0.10</td>
<td>2.48 ±0.172</td>
<td>2.82 ±0.14</td>
<td>2.96 ±0.101</td>
<td>2.70 ±0.228</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>3.175 ±0.147</td>
<td>2.16 ±0.101</td>
<td>3.72 ±0.213</td>
<td>2.64 ±0.215</td>
<td>2.38 ±0.23</td>
<td>3.38 ±0.172</td>
<td>3.64 ±0.300</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>2.70 ±0.244</td>
<td>2.48 ±0.16</td>
<td>2.32 ±0.172</td>
<td>2.40 ±0.178</td>
<td>2.46 ±0.185</td>
<td>3.40 ±0.282</td>
<td>2.54 ±0.162</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>2.68 ±0.17</td>
<td>2.68 ±0.130</td>
<td>2.74 ±0.135</td>
<td>2.54 ±0.257</td>
<td>2.62 ±0.172</td>
<td>2.72 ±0.16</td>
<td>2.56 ±0.215</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>3.22 ±0.172</td>
<td>3.96 ±0.101</td>
<td>2.96 ±0.101</td>
<td>4.16 ±0.185</td>
<td>3.20 ±0.14</td>
<td>4.28 ±0.172</td>
<td>3.60 ±0.129</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>100% M.E.</td>
<td>3.20 ±0.228</td>
<td>3.54 ±0.21</td>
<td>4.46 ±0.162</td>
<td>3.94 ±0.101</td>
<td>3.98 ±0.172</td>
<td>2.36 ±1.132</td>
<td>2.41 ±0.100</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Note: Unit: Urine protein in g/L.  
N.D.: Not Determined.  
All alterations are statistically significant - P < 0.01.
GRAPH NO. 13: URINE - PROTEINS

Units: g/L

<table>
<thead>
<tr>
<th></th>
<th>0.01% M.E.</th>
<th>0.1% M.E.</th>
<th>1% M.E.</th>
<th>5% M.E.</th>
<th>10% M.E.</th>
<th>50% M.E.</th>
<th>100% M.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hours:
- Control
- 6
- 12
- 24
- 48
- 72
- 96
- 120
- 720
- 1080
E] UREA:

The changes in the urinary clearance of urea under the influence of different concentrations of mining effluents at various time intervals are compiled in Table No. 14 and are graphically presented in Graph No. 14. The urea from the urine is expressed as milligrams of urea per hundred millilitre of urine. The control birds showed 16.70 ± 2.07 mg of urea in the urine.

From the graph it appears that the renal clearance of urea was profusely influenced by the mining effluents and the renal clearance of urea showed dose (concentration of M.E.) dependency at the end of twelve hours but such a relationship was not observed for any other time interval under investigation. The maximum renal clearance of urea was observed at the end of one twenty hours under the influence of 100% M.E.

The ducks exposed to 0.01% M.E. did not exhibit any significant change in the renal clearance of urea up to the end of twenty nine days, but at the end of thirty days (seven hundred and twenty hours) the urea level increased to 19.8 ± 3.10 mg/litre while at the end of one thousand and eighty hours the urea level raised to 32.9 ± 4.90 mg/litre.

The 0.1% M.E. exposure promoted fluctuations in the renal clearance of urea. The maximum clearance was observed at the end of one twenty hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the urea concentration in the urine was equivalent to 17.0 ± 5.5, 20.1 ± 3.0, 19.3 ± 1.9, 24.0 ± 2.7, 21.23 ± 2.9, 22.0 ± 3.5 and 27.0 ± 4.10 mg/litre respectively.

The birds exposed to 1.0% M.E. showed steady increase in the urea clearance up to the end of fortyeight hours, but at the later hours the urea clearance showed fluctuations. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the renal
clearance of urea was equivalent to 19.0 ± 4.9, 21.0 ± 5.1, 23.0 ± 3.9, 24.0 ± 1.40, 19.7 ± 2.0, 26.90 ± 2.2 and 25.0 ± 2.9 mg/litre respectively.

The 5.0% M.E. influenced the renal clearance of urea significantly and the maximum clearance was found at the end of ninetysix hours. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the renal clearance of urea was equivalent to 21.3 ± 4.2, 23.0 ± 3.01, 27.70 ± 4.20, 20.20 ± 1.7, 29.0 ± 1.9, 30.3 ± 2.7 and 29.7 ± 2.9 mg/litre respectively.

Under the influence of 10.0% M.E. the ducks showed maximum renal clearance of urea at the end of one twenty hours and the urea concentration of the urine varied between 18.3 mg and 39.0 mg. The urea contents of the urine were equivalent to 18.3 ± 3.7, 23.5 ± 2.7, 27.0 ± 3.2, 30.2 ± 5.4, 37.0 ± 3.8, 29.3 ± 2.2 and 39.0 ±1.01 mg/litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 50.0% M.E. induced significant alterations in the renal clearance of urea and the urea clearance showed time dependent elevation up to the end of seventy two hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the renal clearance of urea was equivalent to 20.70 ± 2.1, 24.0 ± 5.4, 33.70 ± 5.1, 35.90 ± 3.8, 48.90 ± 4.0, 40.20 ± 2.10 and 42.30 ± 2.56 mg/litre respectively.

The ducks exposed to 100.0% M.E. promoted successive increase in the renal clearance of urea for all the time intervals under study except ninetysix hours. The maximum urea concentration was found at the end of one twenty hours.

Thus, the renal clearance of urea at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours was equivalent to 27.3 ± 2.1, 29.0 ± 2.2, 34.0 ± 3.0, 37.9 ± 3.2, 49.7 ± 4.8, 47.0 ± 5.7 and 53.70 ± 3.0 mg/litre respectively.
TABLE NO. 14 : THE CHANGES IN THE UREA EXCRETION OF MALLARDS UNDER THE INFLUENCE OF MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>16.70 ±2.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td>17.0 ±5.50</td>
<td>20.10 ±3.0</td>
<td>19.30 ±1.90</td>
<td>24.0 ±2.70</td>
<td>21.23 ±2.90</td>
<td>22.0 ±3.50</td>
<td></td>
<td>19.80 ±3.10</td>
<td>32.90 ±4.90</td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td>19.0 ±4.90</td>
<td>21.0 ±5.10</td>
<td>23.0 ±3.90</td>
<td>24.0 ±1.40</td>
<td>19.70 ±2.0</td>
<td>26.90 ±2.20</td>
<td>25.0 ±2.90</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td>21.30 ±4.20</td>
<td>23.0 ±3.01</td>
<td>27.70 ±4.20</td>
<td>20.20 ±1.70</td>
<td>29.0 ±1.90</td>
<td>30.30 ±2.70</td>
<td>29.70 ±2.90</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td>18.30 ±3.70</td>
<td>23.50 ±2.70</td>
<td>27.0 ±3.20</td>
<td>30.20 ±5.40</td>
<td>37.0 ±3.80</td>
<td>29.30 ±2.20</td>
<td>39.0 ±1.01</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td>20.70 ±2.10</td>
<td>24.0 ±5.40</td>
<td>33.70 ±5.10</td>
<td>35.90 ±3.80</td>
<td>48.90 ±4.0</td>
<td>40.20 ±2.10</td>
<td>42.30 ±2.56</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td>27.30 ±2.10</td>
<td>29.0 ±2.20</td>
<td>34.0 ±3.0</td>
<td>37.90 ±3.20</td>
<td>49.70 ±4.80</td>
<td>47.0 ±5.70</td>
<td>53.70 ±3.0</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note : Unit : Urea in mg/100ml.
N.D. : Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 14: URINE - UREA
Units: mg/100 ml.

mg/100ml

Hours
F] URIC ACID:

The changes in the uric acid contents of the urine of mallards exposed to various concentrations of mining effluents at different time intervals are tabulated in Table No. 15 and are graphically expressed in Graph No. 15. The birds are uricotelic, therefore normally the ducks excrete 19.0 ± 2.3 milligrams of uric acid per dL of urine. The uric acid in the urine is expressed as milligrams per dL of the urine.

It is evident from the table that the mining effluents promoted wide but significant fluctuations in uric acid excretion. The highest concentration of uric acid was observed at the end of ninetysix hours under the influence of 5% M.E. while the lowest excretion of uric acid was seen at the end of fortyeight hours under the influence of 10.0% M.E.

The mallards exposed to 0.01% M.E. did not exhibit any significant change in the uric acid clearance up to the end of twentynine days, but at the end of thirty days (Seven twenty hours) there was slight increase in the uric acid level and it went on increasing up to the end of one thousand and eighty hours. Thus, the uric acid level at the end of seven twenty and one thousand and eighty hours was equivalent to 23.70 ± 1.7 and 39.732 ± 2.57 mg/dL respectively.

The 0.1% M.E. induced fluctuations in the renal clearance of uric acid. The maximum clearance of uric acid was observed at the end of seventytwo hours, while the minimum was observed at the end of ninetysix hours. The renal clearance of uric acid was equivalent to 20.1 ± 2.85, 22.3 ± 3.0, 24.1 ± 1.41, 19.78 ± 2.0, 25.1 ± 2.315, 18.3 ± 1.85 and 20.9 ± 1.62 mg/dL at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.
The birds exposed to 1.0% M.E. showed fluctuations in the uric acid clearance and the minimum clearance was observed at the end of twelve hours while the maximum clearance was observed at the end of ninety-six hours. Thus, at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninety-six and one twenty hours the renal clearance of uric acid was equivalent to 25.0 ± 3.2, 12.0 ± 2.2, 26.279 ± 1.01, 20.87 ± 3.12, 24.0 ± 2.4, 29.0 ± 2.6 and 20.837 ± 1.6 mg/dL respectively.

The ducks treated with 5.0% M.E. showed wide fluctuations in the uric acid clearance. The highest renal clearance of uric acid was observed at the end of ninety-six hours, while the lowest clearance was observed at the end of six hours. The urinary uric acid concentrations were equivalent to 19.2 ± 2.4, 28.3 ± 2.8, 76.4 ± 3.1, 25.1 ± 2.56, 23.9 ± 4.8, 87.0 ± 5.3 and 31.5 ± 1.01 mg/dL at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninety-six and one twenty hours respectively.

The 10.0% M.E. promoted maximum renal clearance at the end of six hours and then the uric acid levels went on decreasing significantly till the end of forty-eight hours. The renal clearance of uric acid at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninety-six and one twenty hours was equivalent to 43.5 ± 2.059, 33.2 ± 1.01, 24.8 ± 1.72, 11.5 ± 2.39, 35.9 ± 1.41, 25.2 ± 1.36 and 19.0 ± 2.2 mg/dL respectively.

The 50.0% M.E. influenced the uric acid clearance significantly. It induced wide fluctuations in the urinary uric acid levels. The uric acid level at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninety-six and one twenty hours was equivalent to 29.7 ± 4.4, 37.0 ± 3.521, 30.9 ± 4.8, 41.73 ± 3.95, 64.7 ± 2.1, 47.0 ± 3.1 and 53.0 ± 3.52 mg/dL respectively.

The ducks exposed to 100.0% M.E. exhibited significant fluctuations in the renal clearance of uric acid. The maximum renal clearance of uric acid was observed at the end of seventy-two hours, while the minimum clearance was seen at the end of twelve hours. Thus, at the end of six, twelve, twenty-four,
fortyeight, seventytwo, ninety-six and one hundred and twenty hours the renal
clearance of uric acid was equivalent to 38.0 ± 2.39, 32.0 ± 2.87, 47.897 ± 1.7,
43.289 ± 2.607, 73.0 ± 3.92, 57.0 ± 3.5 and 69.0 ± 4.31 mg/dL respectively.
TABLE NO. 15: THE EFFECT OF MINING EFFLUENTS ON URINE - URIC ACID LEVELS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>19.0</td>
<td>±2.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td>20.1</td>
<td>22.3</td>
<td>24.1</td>
<td>19.78</td>
<td>25.10</td>
<td>18.30</td>
<td>20.9</td>
<td>23.70</td>
<td>39.732</td>
</tr>
<tr>
<td></td>
<td>±2.85</td>
<td>±3.0</td>
<td>±1.41</td>
<td>±2.0</td>
<td>±2.315</td>
<td>±1.85</td>
<td>±1.62</td>
<td>±1.70</td>
<td>±2.57</td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>25.0</td>
<td>12.0</td>
<td>26.279</td>
<td>20.872</td>
<td>24.0</td>
<td>29.0</td>
<td>20.837</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±3.2</td>
<td>±2.2</td>
<td>±1.01</td>
<td>±3.12</td>
<td>±2.4</td>
<td>±2.6</td>
<td>±1.6</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>19.2</td>
<td>28.3</td>
<td>76.4</td>
<td>25.1</td>
<td>23.9</td>
<td>87.0</td>
<td>31.5</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±2.4</td>
<td>±2.8</td>
<td>±3.1</td>
<td>±2.56</td>
<td>±4.8</td>
<td>±5.3</td>
<td>±1.01</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>43.5</td>
<td>33.2</td>
<td>24.8</td>
<td>11.5</td>
<td>35.9</td>
<td>25.2</td>
<td>19.0</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±2.059</td>
<td>±1.01</td>
<td>±1.72</td>
<td>±2.39</td>
<td>±1.41</td>
<td>±1.36</td>
<td>±2.2</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>29.7</td>
<td>37.0</td>
<td>30.90</td>
<td>41.73</td>
<td>64.70</td>
<td>47.0</td>
<td>53.0</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±4.4</td>
<td>±3.521</td>
<td>±4.8</td>
<td>±3.95</td>
<td>±2.1</td>
<td>±3.1</td>
<td>±3.52</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>38.0</td>
<td>-32.0</td>
<td>47.897</td>
<td>43.289</td>
<td>73.0</td>
<td>57.0</td>
<td>69.0</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±2.39</td>
<td>±2.87</td>
<td>±1.7</td>
<td>±2.607</td>
<td>±3.92</td>
<td>±3.5</td>
<td>±4.31</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>100% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Note:  Unit: Uric acid in mg/dl.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 15: URINE - URIC ACID
Units: mg/dL of the urine.
G] CREATININE :

The Table No. 16 shows the alterations in the urine creatinine level of the ducks exposed to mining effluents in different concentrations at different time intervals while these changes are graphically given in Graph No. 16. The creatinine concentrations of the urine are expressed as milligrams per litre of the urine. The control birds showed the renal clearance of creatinine equal to 0.08 ± 0.01 mg/L.

From the graph it is evident that the renal clearance of creatinine was dose dependent at the end of six and twelve hours, while at the rest of the time intervals it did not exhibit such relationship. The mallards exposed to 0.01% M.E. did not exhibit any significant change in the urine creatinine levels up to the end of twenty-nine days but at the end of thirty days there was significant increase in the creatinine clearance which further increased at the end of one thousand and eighty hours. Thus, at the end of seven twenty and one thousand eighty hours the urine creatinine level was equivalent to 0.248 ± 0.038 and 0.731 ± 0.051 milligrams per litre of urine.

The ducks exposed to 0.1% of M.E. showed significant fluctuations in the renal clearance of creatinine and the maximum clearance was observed at the end of one twenty hours, while the minimum clearance was seen at the end of forty-eight hours. The renal clearance of creatinine was equivalent to 0.37 ± 0.010, 0.43 ± 0.040, 0.34 ± 0.030, 0.25 ± 0.078, 0.73 ± 0.060, 0.84 ± 0.050 and 1.32 ± 0.021 mg/L at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninetysix and one twenty hours respectively.

The 1.0% M.E. promoted maximum clearance of creatinine at the end of one twenty hours, while the minimum clearance was seen at the end of twenty four hours. But in general the renal clearance of creatinine was at least four fold higher than that observed for the control ones. The creatinine clearance at
the end of one twenty hours was about twenty fold more than that found for the controls. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the urine creatinine values were equivalent to 0.43 ± 0.029, 0.890 ± 0.14, 0.37 ± 0.037, 0.587 ± 0.11, 1.237 ± 0.115, 0.789 ± 0.020, 1.602 ± 0.0344 mg/L respectively.

Under the influence of 5.0% M.E. the ducks showed the progressive increase in the renal clearance of creatinine upto the end of twentyfour hours, while at the rest of the time intervals it showed significant fluctuations. The increase in the renal clearance of creatinine at the end of seventy two hour was over twentynine fold. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the renal clearance of creatinine was equivalent to 0.80 ± 0.03, 0.92 ± 0.042, 1.9 ± 0.035, 1.57 ± 0.101, 2.38 ± 0.01, 1.80 ± 0.231 and 1.30 ± 0.135 mg/L respectively.

The birds exposed to 10.0% M.E. showed wide fluctuations in the renal clearance of creatinine. The maximum clearance of creatinine was observed at the end of ninetysix hours. The creatinine clearance was equivalent to 1.10 ± 0.07, 1.0 ± 0.020, 0.7 ± 0.016, 1.20 ± 0.08, 1.50 ± 0.060, 2.10 ± 0.01 and 1.20 ± 0.010 mg/L at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

Under the influence of 50.0% M.E. the renal clearance of creatinine increased significantly, especially at the end of ninetysix, hours, it was fortyfold more than that observed in the control ones. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the renal clearance of creatinine was equivalent to 1.60 ± 0.18, 1.80 ± 0.16, 2.10 ± 0.10, 2.8 ± 0.101, 3.10 ± 0.271, 3.20 ± 0.37 and 2.78 ± 0.256 mg/L respectively.

The 100.0% M.E. induced fluctuations in the renal clearance of creatinine and the maximum creatinine clearance was observed at the end of seventytwo hours, while the minimum clearance was observed at the end of six hours. The creatinine values of the urine were equivalent to 1.90 ± 0.162, 2.70
± 0.116, 2.0 ± 0.13, 2.10 ± 0.426, 3.0 ± 0.162, 2.80 ± 0.377 and 2.0 ± 0.120 mg/L at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours respectively.
### TABLE NO. 16: EFFECT OF MINING EFFLUENT ON THE URINE CREATININE LEVEL.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>0.08 ± 0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.248 ± 0.038</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.731 ± 0.051</td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: Creatinine in mg/litre.

N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 16: URINE - CREATININE

Units: mg/L

Hours

mg/L

Control 6 12 24 48 72 96 120 720 1080
H] CALCIUM:

The changes in the renal clearance of calcium under the influence of mining effluents of various concentrations at different time intervals are tabulated in Table No. 17 and graphically presented in Graph No. 17. The renal calcium clearance is expressed as milligrams of calcium per dL of urine. The control birds showed the renal clearance i.e. urine calcium level equivalent to 1.4 ± 0.236 mg per dL.

From the table and graph it is seen that the highest renal calcium clearance was induced by 100% M.E. at the end of twenty four hours, while the lowest calcium clearance was induced by 1.0% M.E. at the end of six hours. However, all the concentrations of M.E. induced renal calcium clearance higher than that of control ones.

The animals exposed to 0.01% M.E. did not exhibit any significant change in the calcium clearance up to the end of twentynine days, but at the end of thirty days (seven twenty hours) and one thousand eighty hours the calcium clearance rose over four and six times the normal levels respectively. Thus, at the end of seven twenty and one thousand and eighty hours, the urine calcium level was equivalent to 5.79 ± 0.40 and 9.32 ± 0.363 milligrams/dL.

The 0.1% M.E. induced fluctuations in the calcium clearance. The maximum urine calcium level was found at the end of one twenty hours, while the lowest was observed at the end of seventytwo hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the urine calcium level was equivalent to 2.7 ± 0.14, 2.70 ± 0.10, 4.60 ± 0.178, 3.44 ± 0.185, 2.66 ± 0.185, 5.64 ± 0.215 and 7.56 ± 0.215 milligrams/dL respectively.

Under the influence of 1.0% M.E. the renal calcium clearance gradually increased upto the end of twentyfour hours but dropped at the end of fortyeight
and seventytwo hours. Then once again, the calcium clearance raised over five times the normal level. The maximum calcium clearance was observed at the end of one twenty hours. Thus, at the end of six, twelve, twentyfour, fortyeight, seventy two, ninety six and one twenty hours, the renal calcium clearance was equivalent to 2.62 ± 0.386, 3.30 ± 0.260, 4.22 ± 0.278, 2.88 ± 0.116, 2.70 ± 0.228 , 7.32 ± 0.925 and 8.12 ± 0.203 milligrams/dL respectively.

The mallards exposed to 5.0% M.E. exhibited fluctuations in the calcium clearance. The renal clearance of calcium was over seven fold at the end of seventy two hours, to that observed in the controls. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the urine calcium level was equivalent to 8.78 ± 0.43, 8.947 ± 0.227, 7.92 ± 0.318, 4.7± 0.209, 10.06 ± 0.287, 9.24 ± 0.272 and 7.48 ± 0.172 milligrams/dL respectively.

Under the influence of 10.0% M.E. the ducks showed significant changes in the renal clearance of calcium. The maximum calcium clearance was observed at the end of one twenty hours, while the minimum was observed at the end of twelve hours. The renal clearance of calcium was equivalent to 7.58 ± 0.213, 5.20 ± 0.140, 7.58 ± 0.074, 6.8 ± 0.240, 8.28 ± 0.667, 8.02 ± 0.172 and 18.52 ± 0.256 milligrams/dL at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 50.0% M.E. promoted wide fluctuations in the renal clearance of calcium and the maximum calcium clearance was induced at the end of twenty-four hours after the steady increase in the clearance through six and twelve hours. The calcium level in the urine at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 11.48 ± 0.172, 12.10 ± 0.340, 13.06 ± 0.241, 7.06 ± 0.287, 8.08 ± 0.292, 6.86 ± 0.101 and 6.2 ± 0.140 milligrams/dL respectively.

The birds exposed to 100.0% M.E. exhibited very high clearance of calcium through urine and over fifteen fold increase in calcium clearance was
observed at the end of twenty-four hours, while a little less than four fold increase in urine calcium level was found at the end of seventy-two hours. Thus, at the end of six, twelve, twenty-four, forty-eight, seventy-two, ninety-six and one twenty hours the urine calcium was equivalent to 20.92 ± 0.457, 18.80 ± 0.283, 22.08 ± 0.271, 9.26 ± 0.210, 5.56 ± 0.215, 9.42 ± 0.172 and 8.50 ± 0.260 milligrams/dL respectively.
TABLE NO. 17: EFFECTS OF MINING EFFLUENTS ON THE RENAL CLEARANCE OF CALCIUM.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.40</td>
<td>±0.238</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01%  M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1%  M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%   M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%   M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%  M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%  M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: Calcium in mg/dL.
N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 17  URINE - CALCIUM
Units : mg/dL
I] CHLORIDE:

The alterations in the chloride contents of the urine under the influence of mining effluents in different concentrations at various time intervals are compiled in Table No. 18 and are graphically given in Graph No. 18. The chlorides from the urine are expressed as milliequivalence per litre of the urine. The control animals exhibited 30.0 ± 1.010 milliequivalence of chlorides in the urine.

From the graph it appears that the mining effluents promoted increases and wide fluctuations in the chloride clearances. The renal clearance of chlorides exhibited M.E. concentration dependency at the end of ninetysix hours and partially at the end of one twenty hours. The 100% M.E. induced the highest clearance of chlorides at the end of seventytwo hours. At the end of seventwenty and one thousand and eighty hours the renal clearance of chlorides was equivalent to 54.74 ± 2.48 and 47.68 ± 0.4 mEq/litre respectively.

The mallards exposed to 0.01% M.E. did not show any change in the renal clearance of chlorides up to the end of twentynine days but at the end of thirty days there was a very significant increase in the chloride clearance. Then at the end of one thousand and eighty hours there was slight decrease in the chloride clearance as compared with the clearance observed at the end of seven twenty hours.

Under the influence of 0.1% M.E. there was an increase in the chloride clearance at the end of six hours and subsequently there was decrease in the urine chloride levels up to the end of fortyeight hours. Then, at the end of seventy two hours there was abrupt increase in the chloride clearance. Thus, the chloride clearance was equivalent to 56.80 ± 0.758, 46.78 ± 1.148, 43.12 ± 0.70, 42.34 ± 0.76, 74.10 ± 1.206, 28.42 ± 1.64 and 39.12 ± 2.678
milliequivalence at the end of six, twelve, twentyfour, fortyeight seventytwo, ninetysix and one twenty hours respectively.

The 1.0 % M.E. induced maximum decrease in the chloride clearance at the end of one twenty hours while a marginal increase was promoted at the end of six and twelve hours. A significant increase in the renal clearance of chlorides was observed at the end of ninetysix hours. The chloride clearance at the end of six, twelve, twentyfour, fortyeight seventytwo, ninetysix and one twenty hours was equivalent to $32.70 \pm 1.47$, $30.82 \pm 0.577$, $19.80 \pm 0.54$, $26.20 \pm 1.720$, $26.05 \pm 0.722$, $54.26 \pm 0.97$ and $12.04 \pm 2.3$ milliequivalence/litre respectively.

The exposure of mallards to 5.0% M.E. promoted time dependent increase in the chloride clearance up to the end of seventy two hours but subsequently it decreased sharply at the end of ninetysix and one twenty hours. Thus, the renal clearance of chlorides was equivalent to $97.0 \pm 0.205$, $100.0 \pm 0.583$, $142.0 \pm 0.612$, $149.0 \pm 1.3$, $151.0 \pm 2.48$, $96.0 \pm 1.148$ and $68.0 \pm 2.17$ milliequivalence/litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

On exposure to 10.0% M.E. the birds showed fluctuations in the chloride clearance. The chloride clearance raised over five fold at the end of six hours and then subsequently went on decreasing up to the end of twentyfour hours. The urine showed the chloride values equivalent to $169.0 \pm 3.1$, $157.0 \pm 1.34$, $146.0 \pm 5.1$, $159.0 \pm 2.1$, $149.0 \pm 1.36$, $163.0 \pm 0.50$ and $170.0 \pm 0.416$ milliequivalence/litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The 50.0% M.E. induced very high chloride clearance at the end of one hundred and twenty hours and the chloride level fluctuated between 44.66 and 265.0 milliequivalence per litre. At the end of six; twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the renal clearance of chloride was
equivalent to 85.0 ± 3.03, 80.0 ± 1.6, 74.0 ± 3.4, 85.0 ± 1.26, 44.66 ± 0.763, 174.80 ± 2.56 and 265.0 ± 2.3 milliequivalence/litre respectively.

The ducks treated with 100.0% M.E. showed very high chloride clearance for all the time intervals under study except fortyeight hours. Initially, the chloride clearance increased sharply at the end of six hours and subsequently continued to increase up to the end of twentyfour hours, but at the end of 48 hours, the chloride clearance dropped sharply but then increased abruptly at the end of seventytwo hours to a peak level. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the renal clearance of chlorides was equivalent to 177.25 ± 1.78, 221.50 ± 2.17, 266.0 ± 2.54, 88.15 ± 1.44, 896.0 ± 1.01, 370.0 ± 5.03 and 576.6 ± 4.31 milliequivalence/litre respectively.
### TABLE NO. 18: EFFECT OF MINING EFFLUENTS ON THE URINE CHLORIDES.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>30.0</td>
<td>±1.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.01% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>±0.758</td>
<td>±1.148</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>±0.4</td>
</tr>
<tr>
<td></td>
<td>56.80</td>
<td>46.78</td>
<td>43.12</td>
<td>42.34</td>
<td>74.10</td>
<td>28.42</td>
<td>39.12</td>
<td>54.74</td>
<td>47.68</td>
</tr>
<tr>
<td></td>
<td>±1.47</td>
<td>±0.577</td>
<td>±0.70</td>
<td>±0.76</td>
<td>±1.206</td>
<td>±1.64</td>
<td>±2.678</td>
<td>±2.48</td>
<td>±0.4</td>
</tr>
<tr>
<td><strong>0.1% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32.70</td>
<td>30.82</td>
<td>19.80</td>
<td>26.20</td>
<td>26.05</td>
<td>54.26</td>
<td>12.04</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±1.47</td>
<td>±0.557</td>
<td>±0.54</td>
<td>±1.720</td>
<td>±0.722</td>
<td>±0.97</td>
<td>±2.3</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>1% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>97</td>
<td>100</td>
<td>142</td>
<td>149</td>
<td>151</td>
<td>96</td>
<td>68</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±0.205</td>
<td>±0.583</td>
<td>±0.612</td>
<td>±1.3</td>
<td>±2.48</td>
<td>±1.148</td>
<td>±2.17</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>5% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>169</td>
<td>157</td>
<td>146</td>
<td>159</td>
<td>149</td>
<td>163</td>
<td>170</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±3.1</td>
<td>±1.34</td>
<td>±5.1</td>
<td>±2.1</td>
<td>±1.36</td>
<td>±0.50</td>
<td>±0.416</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>10% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>85.0</td>
<td>80.0</td>
<td>74.0</td>
<td>85.0</td>
<td>44.66</td>
<td>174.80</td>
<td>265.0</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±3.03</td>
<td>±1.6</td>
<td>±3.4</td>
<td>±1.26</td>
<td>±0.763</td>
<td>±2.56</td>
<td>±2.3</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>50% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>177.25</td>
<td>221.5</td>
<td>266.0</td>
<td>88.15</td>
<td>896.0</td>
<td>370.0</td>
<td>576.6</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td>±1.78</td>
<td>±2.17</td>
<td>±2.54</td>
<td>±1.44</td>
<td>±1.01</td>
<td>±5.03</td>
<td>±4.31</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td><strong>100% M.E.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Unit: Chlorides in mEqs/L.

N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 18: URINE - CHLORIDE

Units - mEq/Litre

0.01% M.E.
0.1% M.E.
1% M.E.
5% M.E.
10% M.E.
50% M.E.
100% M.E.

mEq/Litre

Control  6  12  24  48  72  96  120  720  1080

Hours
ALTERATIONS IN URINE ELECTROLYTES:

a) SODIUM:

The variations in the renal clearance of sodium under the influence of mining effluents are compiled in Table No. 19 and are given graphically in Graph No. 19. The sodium clearance is expressed as milliequivalence per litre of the urine. The control animals exhibited renal clearance of Na⁺ equivalent to 62.0 ± 4.1 milliequivalence/litre.

From the graph it is evident that the mining effluents had a pronounced influence on the Na⁺ clearance and generally at all the time intervals there was increased Na⁺ clearance. The M.E. induced wide fluctuations in Na⁺ clearance and the highest renal clearance of Na⁺ was promoted at the end of seventytwo hours under the influence of 100.0% M.E., while the minimum of 68.2 milliequivalence/litre clearance was induced at the end of twentyfour hours under the influence of 0.1% M.E.

The animals exposed to 0.01% M.E. did not show any significant change in the Na⁺ clearance up to the end of twenty nine days but at the end of the thirtydays the renal clearance of Na⁺ increased to 72.4 ± 1.62 milliequivalence/litre and went on increasing to 91.40 ± 1.74 milliequivalence/litre at the end of one thousand and eighty hours.

The 0.1% M.E. promoted significant fluctuations in the renal clearance of sodium but in general the Na⁺ clearance was higher than that observed in the controls. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the Na⁺ clearance was equivalent to 69.40 ± 1.01, 79.0 ± 0.63, 68.20 ± 1.72, 80.0 ± 4.4, 83.60 ± 3.87, 72.60 ± 1.62 and 73.20 ± 2.315 milliequivalence/litre respectively.

Under the influence of 1.0% M.E. the ducks showed variations in the Na⁺ clearance and the Na⁺ clearance was equivalent to 87.0 ± 1.41, 74.4 ±
The ducks exposed to 5.0% M.E. showed sharp increase in \( \text{Na}^+ \) clearance at the end of six hours but, later on, it declined gradually up to the end of fortyeight hours. Then, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and onetwenty hours the \( \text{Na}^+ \) clearance was equivalent to 93.20 ± 2.1, 85.40 ± 2.24, 80.80 ± 2.22, 70.80 ± 1.4, 85.0 ± 3.0, 91.40 ± 6.0 and 79.0 ± 1.4 milliequivalence/litre respectively.

The treatment of 10.0% M.E. promoted significant fluctuations in the renal clearance of \( \text{Na}^+ \). The maximum \( \text{Na}^+ \) clearance was observed at the end of seventytwo hours. The renal clearance of \( \text{Na}^+ \) was equivalent to 73.20 ± 2.1, 79.20 ± 1.93, 73.20 ± 2.1, 84.20 ± 2.13, 88.80 ± 1.166, 79.20 ± 2.03 and 83.80 ± 2.48 milliequivalence/litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The ducks exposed to 50.0% M.E. showed high clearance of \( \text{Na}^+ \) but there were fluctuations in the \( \text{Na}^+ \) clearance for different time intervals. The renal clearance of \( \text{Na}^+ \) at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 73.0 ± 2.0, 86.0 ± 2.4, 77.20 ± 3.70, 94.20 ± 1.16, 99.20 ± 1.70, 93.20 ± 2.5 and 91.40 ± 4.6 milliequivalence/litre respectively.

The 100.0% M.E. induced highest renal clearance of \( \text{Na}^+ \) at the end of seventy two hours and at all the time intervals under investigation the \( \text{Na}^+ \) clearance was about three fold more than that observed in the control animals. Thus at the end of six, twelve, twenty four, fortyeight, seventytwo, ninetysix, and one twenty hours the renal clearance of \( \text{Na}^+ \) was equivalent to 91.80 ± 1.70, 88.80 ± 2.85, 100.60 ± 1.85, 91.40 ± 1.62, 101.20 ± 3.10, 99.40 ± 1.01 and 100.60 ± 1.35 milliequivalence/litre respectively.
### TABLE NO. 19: RENAL CLEARANCE OF SODIUM UNDER THE INFLUENCE OF MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>62.0</td>
<td>±4.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1% M.E.</td>
<td>69.40</td>
<td>±1.01</td>
<td>79.0</td>
<td>±0.63</td>
<td>68.20</td>
<td>±1.72</td>
<td>80.0</td>
<td>±4.4</td>
<td>83.60</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>87.0</td>
<td>±1.41</td>
<td>74.40</td>
<td>±2.8</td>
<td>86.20</td>
<td>±1.7</td>
<td>93.20</td>
<td>±2.1</td>
<td>68.80</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>93.20</td>
<td>±2.1</td>
<td>85.40</td>
<td>±2.24</td>
<td>80.80</td>
<td>±2.22</td>
<td>70.80</td>
<td>±1.4</td>
<td>85.0</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>73.20</td>
<td>±2.1</td>
<td>79.20</td>
<td>±1.93</td>
<td>73.20</td>
<td>±2.1</td>
<td>84.20</td>
<td>±2.13</td>
<td>88.80</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>73.0</td>
<td>±2.0</td>
<td>86.0</td>
<td>±2.4</td>
<td>77.20</td>
<td>±3.7</td>
<td>94.20</td>
<td>±1.16</td>
<td>99.20</td>
</tr>
<tr>
<td>100% M.E.</td>
<td>91.80</td>
<td>±1.7</td>
<td>88.80</td>
<td>±2.85</td>
<td>100.60</td>
<td>±1.85</td>
<td>91.40</td>
<td>±1.62</td>
<td>101.20</td>
</tr>
</tbody>
</table>

**Note:** Unit: Sodium in mEq/Litre.

N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 19: URINE - SODIUM
Units: mEq/L.
b] POTASSIUM :

The changes in the renal clearance of $K^+$ under the influence of mining effluents are compiled in Table No. 20 and are graphically presented in Graph No. 20. The renal clearance of $K^+$ is expressed in milliequivalence (mEq) per litre of the urine. The control animals showed $K^+$ clearance equivalent to 4.20 ± 0.18 milliequivalence per litre.

From the graph it appears that the renal clearance of $K^+$ was dose dependent i.e. concentration dependent at the end of fortyeight hours and 100% M.E. induced significantly higher renal clearance of $K^+$.

When the ducks were exposed to 0.01% M.E. there was no significant change in the renal clearance of potassium up to the end of twenty nine days but at the end of thirty days (seven twenty hours) there was an increase in $K^+$ clearance which further increased at the end of one thousand and eighty hours. Thus, the $K^+$ clearance was equivalent to 5.60 ± 0.20 and 8.46 ± 0.101 milliequivalence per litre at the end of seven twenty and one thousand eighty hours respectively.

The 0.1% M.E. induced fluctuations in the renal clearance of $K^+$ and a relatively higher clearance was observed at the end of ninetysix hours. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix, and one twenty hours the renal clearance of $K^+$ was equivalent to 6.72 ± 0.07, 5.60 ± 0.20, 7.14 ± 0.16, 5.80 ± 0.158, 5.0 ± 0.06, 7.225 ± 0.129 and 5.38 ± 0.09 milliequivalence per litre respectively.

The 1.0% M.E. promoted significant variations in the $K^+$ clearance. The renal clearance of $K^+$ at the end of six, twelve, twentyfour fortyeight, seventytwo, ninetysix and one twenty hours was equivalent to 7.34 ± 0.101, 5.78 ± 0.116, 7.22 ± 0.11, 6.16 ± 0.10, 8.28 ± 0.11, 5.0 ± 0.141 and 6.84 ± 0.101 milliequivalence per litre respectively.
Under the influence of 5.0% M.E. there was significant rise in K+ clearance at the end of six and twelve hours but subsequently the K+ clearance went on decreasing up to the end of ninetysix hours. Thus, the K+ clearance was equivalent to 8.36 ± 0.135, 9.46 ± 0.185, 8.0 ± 0.167, 6.58 ± 0.203, 7.64 ± 0.21, 5.62 ± 0.172 and 7.48 ± 0.22 milliequivalence per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The ducks subjected to 10.0% M.E. exhibited high K+ clearance but the K+ clearance was fluctuating between 7.20 and 9.82 milliequivalence per litre. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the renal clearance of K+ was equivalent to 7.20 ± 0.132, 8.40 ± 0.248, 7.50 ± 0.30, 9.16 ± 0.546, 9.82 ± 0.172, 9.08 ± 0.450 and 9.44 ± 0.17 milliequivalence per litre respectively.

The 50.0% M.E. promoted very high clearance of K+ and the maximum clearance was observed at the end of twelve hours, while the minimum clearance was observed at the end of one twenty hours. Thus, the renal clearance of K+ was equivalent to 12.98 ± 0.13, 14.92 ± 0.17, 12.04 ± 0.162, 9.21 ± 0.134, 12.46 ± 0.23, 8.76 ± 0.12 and 5.44 ± 0.20 milliequivalence per litre at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours respectively.

The mallard subjected to 100.0% M.E. showed the highest renal clearance of K+ at the end of six hours and the minimum at the end of one twenty hours. Thus, at the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one twenty hours the renal clearance of K+ was equivalent to 17.86 ± 6.30, 11.34 ± 0.215, 14.98 ± 0.222, 13.14 ± 0.307, 17.0 ± 0.316, 12.0 ± 0.66 and 10.66 ± 0.162 milliequivalence per litre respectively.
TABLE NO. 20 : THE VARIATION IN POTASSIUM CLEARANCE UNDER THE INFLUENCE OF MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01%</td>
<td>M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No significant change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>±0.101</td>
</tr>
<tr>
<td>0.1%</td>
<td>M.E.</td>
<td>6.72</td>
<td>5.60</td>
<td>7.14</td>
<td>5.80</td>
<td>5.0</td>
<td>7.225</td>
<td>5.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.07</td>
<td>±0.2</td>
<td>±0.16</td>
<td>±0.158</td>
<td>±0.06</td>
<td>±0.129</td>
<td>±0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>M.E.</td>
<td>7.34</td>
<td>5.78</td>
<td>7.22</td>
<td>6.16</td>
<td>8.28</td>
<td>5.0</td>
<td>6.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.101</td>
<td>±0.116</td>
<td>±0.10</td>
<td>±0.10</td>
<td>±0.11</td>
<td>±0.141</td>
<td>±0.101</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>M.E.</td>
<td>8.36</td>
<td>9.46</td>
<td>8.0</td>
<td>6.58</td>
<td>7.64</td>
<td>5.62</td>
<td>7.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.135</td>
<td>±0.185</td>
<td>±0.167</td>
<td>±0.203</td>
<td>±0.21</td>
<td>±0.172</td>
<td>±0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>M.E.</td>
<td>7.20</td>
<td>8.40</td>
<td>7.50</td>
<td>9.16</td>
<td>9.82</td>
<td>9.08</td>
<td>9.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.132</td>
<td>±0.248</td>
<td>±0.3</td>
<td>±0.546</td>
<td>±0.172</td>
<td>±0.45</td>
<td>±0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>M.E.</td>
<td>12.98</td>
<td>14.92</td>
<td>12.04</td>
<td>9.21</td>
<td>12.46</td>
<td>8.76</td>
<td>5.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.13</td>
<td>±0.17</td>
<td>±0.162</td>
<td>±0.134</td>
<td>±0.23</td>
<td>±0.12</td>
<td>±0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>M.E.</td>
<td>17.86</td>
<td>11.34</td>
<td>14.98</td>
<td>13.14</td>
<td>17.0</td>
<td>12.0</td>
<td>10.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±6.30</td>
<td>±0.215</td>
<td>±0.222</td>
<td>±0.307</td>
<td>±0.316</td>
<td>±0.66</td>
<td>±0.162</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: Potassium in mEqs / Litre.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 20: URINE - POTASSIUM

Units: mEq/L
c] CHANGES IN URINE FLOW:

The changes in the urine flow are given in Table No 20-A and are graphically presented in the Graph No 20-A. The rates of urine flow are expressed as millilitres of urine per Kilogram body weight per minute. The control ducks exhibited urine flow equivalent to 0.166 ± 0.001 ml/kg/min.

From the table and the graph it appears that almost all the concentrations of mining effluents (M.E.) induced concentration dependent and exposure period dependent changes in the urine flow barring a few exceptions. The very low concentration like 0.01% M.E. did not induce any change in the rate of urine flow up to the end of twenty nine days but at the end of thirty days the rate of urine flow decreased significantly and kept on decreasing up to the end of fortyfive days. The rate of urine flow at the end of thirty and fortyfive days was equivalent to 0.137 ± 0.02 and 0.132 ± 0.03 ml/kg/min. The 0.1% M.E. induced progressive decrease in the rate of urine flow. By the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the urine flow was equivalent to 0.165 ± 0.03, 0.159 ± 0.04, 0.154 ± 0.03, 0.150 ± 0.04, 0.150 ± 0.05, 0.143 ± 0.01 and 0.140 ± 0.01 millilitre/kg/min respectively. The 1.0% M.E. also induced reduction in the urine flow in the progressive manner from the end of six hours to the end of one hundred and twenty hours. By the end of six, twelve, twentyfour, fortyeight, seventy two, ninety six and one hundred and twenty hours the rate of urine flow was equivalent to 0.162 ± 0.03, 0.157 ± 0.01, 0.155 ± 0.03, 0.149 ± 0.04, 0.147 ± 0.05, 0.145 ± 0.01 and 0.139 ± 0.02 ml/kg/min respectively.

The 5.0% M.E. induced reduction in the rate of urine flow. By the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours, the rate of urine flow was equivalent to 0.162 ± 0.001, 0.159 ±
0.03, 0.154 ± 0.02, 0.147 ± 0.03, 0.139 ± 0.05, 0.140 ± 0.01 and 0.131 ± 0.02 ml/kg/min respectively.

Under the influence of 10.0% M.E. the ducks exhibited reduction in the rate of urine flow. At the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the rate of urine flow was equivalent to 0.160 ± 0.01, 0.158 ± 0.03, 0.149 ± 0.04, 0.150 ± 0.02, 0.153 ± 0.01, 0.139 ± 0.03 and 0.129 ± 0.06 ml/kg/min respectively.

The ducks subjected to 50.0% M.E. showed sharp reduction in the urine flow. By the end of six, twelve, twentyfour, forty eight, seventy two, ninetysix and one hundred and twenty hours the rate of urine flow was equivalent to 0.158 ± 0.01, 0.155 ± 0.001, 0.143 ± 0.03, 0.142 ± 0.01, 0.132 ± 0.01, 0.121 ± 0.02 and 0.118 ± 0.002 ml/kg/min respectively.

The exposure of mallards to 100.0% M.E. promoted reduction in the rate of urine flow. By the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours the rate of urine flow was equivalent to 0.167 ± 0.001, 0.143 ± 0.003, 0.139 ± 0.004, 0.140 ± 0.001, 0.123 ± 0.01, 0.108 ± 0.02 and 0.101 ± 0.001 ml/kg/min respectively. All the reductions in the rate of urine flow were statistically significant (P< 0.01).
| TABLE NO. 20A : CHANGES IN URINE FLOW UNDER THE INFLUENCE OF MINING EFFLUENTS. |
|---------------------------------|------------------|--|--|--|--|--|--|--|--|---|
|                                 | 6 Hours | 12 Hours | 24 Hours | 48 Hours | 72 Hours | 96 Hours | 120 Hours | 720 Hours | 1080 Hours |
| Control                        | 0.001 ± 0.1669 |          |          |          |          |          |           |           |            |
| 0.01% M.E.                    | 0.165 ± 0.03 | 0.159 ± 0.04 | 0.154 ± 0.03 | 0.150 ± 0.04 | 0.150 ± 0.05 | 0.143 ± 0.01 | 0.140 ± 0.01 | 0.137 ± 0.02 | 0.132 ± 0.03 |
| 0.10% M.E.                    | 0.162 ± 0.03 | 0.157 ± 0.01 | 0.155 ± 0.03 | 0.149 ± 0.04 | 0.147 ± 0.05 | 0.145 ± 0.01 | 0.139 ± 0.02 | N.D. | N.D. |
| 1% M.E.                       | 0.162 ± 0.001 | 0.159 ± 0.03 | 0.154 ± 0.01 | 0.147 ± 0.05 | 0.139 ± 0.01 | 0.140 ± 0.02 | N.D. | N.D. |
| 5% M.E.                       | 0.160 ± 0.01 | 0.158 ± 0.03 | 0.149 ± 0.04 | 0.150 ± 0.02 | 0.153 ± 0.01 | 0.139 ± 0.06 | 0.129 ± 0.01 | N.D. | N.D. |
| 10% M.E.                      | 0.158 ± 0.01 | 0.155 ± 0.001 | 0.143 ± 0.03 | 0.142 ± 0.01 | 0.132 ± 0.02 | N.D. | N.D. | N.D. |
| 50% M.E.                      | 0.167 ± 0.001 | 0.143 ± 0.003 | 0.139 ± 0.004 | 0.140 ± 0.001 | 0.123 ± 0.001 | 0.108 ± 0.002 | 0.101 ± 0.002 | N.D. | N.D. |
| 100% M.E.                     |          |          |          |          |          |          |           |           |            |

Note: Unit: ml/min.
N.D.: Not Determined.
All alterations are statistically significant - P < 0.01.
GRAPH NO. 20 A : RATE OF URINE FORMATION.
Units : ml/minute

- Rate of urine formation is measured in ml/minute.
- The graph shows the rate of urine formation over time (in hours) for different concentrations of M.E.
- The concentrations tested are 0.01%, 0.1%, 1%, 5%, 10%, 50%, and 100% M.E.
- The rates are indicated by bars on the graph, with each concentration having a unique pattern.
1.937 ± 0.3, 1.954 ± 0.4, 1.845 ± 0.1, 1.837 ± 0.7 and 1.828 ± 0.3 ml/kg/min respectively.

The exposure of ducks to 10.0% M.E. introduced reductions in GFR at the various time intervals and the GFR was equivalent to 1.978 ± 0.31, 1.872 ± 0.21, 1.910 ± 0.17, 1.832 ± 0.189, 1.891 ±0.193, 1.871 ± 0.17 and 1.798 ± 0.189 ml/kg/min at the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one hundred and twenty hours respectively.

On exposing the ducks to 50.0% M.E. the GFR reduced significantly and then went on declining progressively as the exposure period increased. At the end of six, twelve, twentyfour, fortyeight, seventy two, ninetysix and one hundred and twenty hours the GFR was equivalent to 1.931 ± 0.2, 1.892 ± 0.3, 1.876 ± 0.17, 1.831 ± 0.18, 1.801 ± 0.2, 1.793 ± 0.31 and 1.741 ± 0.178 ml/kg/min respectively.

The 100.0% M.E. induced sharp reductions in the GFR. By the end of six, twelve, twentyfour, fortyeight, seventytwo, ninetysix and one hundred and twenty hours, the GFR was equivalent to 1.890 ± 0.3, 1.738 ± 0.178, 1.701 ± 0.21, 1.639 ± 0.231, 1.648 ± 0.1, 1.732 ± 0.12 and 1.579 ± 0.17 ml/kg/min respectively.

All the reductions in GFR were statistically significant (P < 0.01).
TABLE NO. 20B : CHANGES IN GLOMERULAR FILTRATION RATE (GFR) UNDER THE INFLUENCE OF MINING EFFLUENTS.

<table>
<thead>
<tr>
<th></th>
<th>6 Hours</th>
<th>12 Hours</th>
<th>24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>96 Hours</th>
<th>120 Hours</th>
<th>720 Hours</th>
<th>1080 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.30</td>
<td>±0.127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01% M.E.</td>
<td>2.01</td>
<td>±0.1</td>
<td>1.98</td>
<td>±0.3</td>
<td>1.973</td>
<td>±0.01</td>
<td>1.985</td>
<td>±0.173</td>
<td>1.975</td>
</tr>
<tr>
<td>0.10% M.E.</td>
<td>1.999</td>
<td>±0.1</td>
<td>1.978</td>
<td>±0.009</td>
<td>1.983</td>
<td>±0.1</td>
<td>1.993</td>
<td>±0.31</td>
<td>1.872</td>
</tr>
<tr>
<td>1% M.E.</td>
<td>1.981</td>
<td>±0.1</td>
<td>1.976</td>
<td>±0.2</td>
<td>1.937</td>
<td>±0.3</td>
<td>1.954</td>
<td>±0.4</td>
<td>1.845</td>
</tr>
<tr>
<td>5% M.E.</td>
<td>1.978</td>
<td>±0.31</td>
<td>1.872</td>
<td>±0.21</td>
<td>1.910</td>
<td>±0.17</td>
<td>1.832</td>
<td>±0.189</td>
<td>1.891</td>
</tr>
<tr>
<td>10% M.E.</td>
<td>1.931</td>
<td>±0.2</td>
<td>1.892</td>
<td>±0.3</td>
<td>1.876</td>
<td>±0.17</td>
<td>1.831</td>
<td>±0.18</td>
<td>1.801</td>
</tr>
<tr>
<td>50% M.E.</td>
<td>1.89</td>
<td>±0.3</td>
<td>1.738</td>
<td>±0.178</td>
<td>1.701</td>
<td>±0.21</td>
<td>1.639</td>
<td>±0.231</td>
<td>1.648</td>
</tr>
<tr>
<td>100% M.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Unit: ml/kg/min.
N.D.: Not Determined.

All alterations are statistically significant - P < 0.01.
GRAPH NO. 20 B: GLOMERULAR FILTRATION RATE IN URINE.
Units: ml/kg/min.

- 0.01% M.E.
- 0.1% M.E.
- 1% M.E.
- 5% M.E.
- 10% M.E.
- 50% M.E.
- 100% M.E.

Control 6 12 24 48 72 96 120 720 1080

Hours

ml/kg/min