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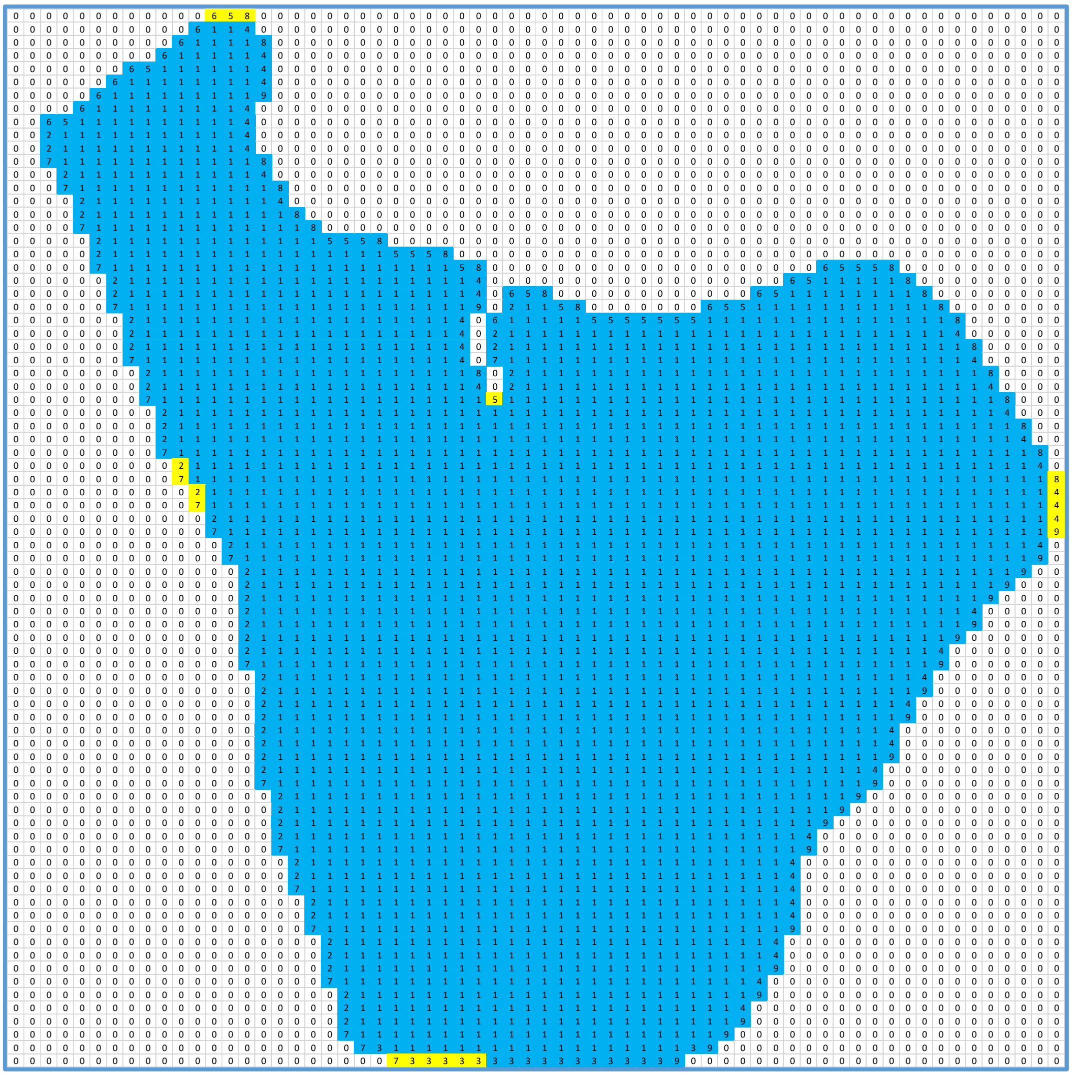
LAMPIRAN

Lampiran 1. File Excel grid komputasi danau unhas yang berisikan kode dari 1 sampai 9



Lampiran 2. Program MATLAB penyebaran logam berat pada danau unhas dengan menggunakan persamaan adveksi-difusi 2-dimensi

```
% Persamaan Adveksi Difusi 2 Dimensi dengan Metode Beda Hingga
%                   Irreguler Boundary Problem
%  Semua Irregular Boundary harus diletakan pada Reguler Grid
dengan kode seperti berikut :
%
%   0-Di Luar                  5-Di Kiri     FSx CSy
%   1-Di Dalam CSx CSy         6-Kiri Bawah  FSx FSy   |_
%   2-Di Bawah CSx CFy         7-Kanan Bawah BSx FSy    _     _|
%   3-Di Kanan BSx CSy         8-Kiri Atas   FSx BSy   |      _
%   4-Di Atas  CSx BSy         9-Kanan Atas  BSx BSy           |

clear all; clc;
% Matriks Danau Unhas
CD = xlsread('D:\ISEKAI\Tugas Akhir\OTW
HASIL\KodeGridDanauUnhas.xlsx','Model 1','B2:BM81');
Nx = 80;               % Jumlah Grid Sumbu x
Ny = 64;               % Jumlah Grid Sumbu y
Delx = 0.5;            % Lebar Grid Sumbu x
Dely = 0.5;            % Lebar Grid Sumbu y
% Difusi Logam Arsen
Dx = 11.11*10^(-8);    % Koefisien Difusi arah x
Dy = 11.11*10^(-8);    % Koefisien Difusi arah y
% Difusi Logam Krom
Dx = 7.3*10^(-8);
Dy = 7.3*10^(-8);
% Difusi Logam Timbal
Dx = 11.6*10^(-8);
Dy = 11.6*10^(-8);
% Kasus 1
Vx = 0;                % Koefisien Adveksi arah x
Vy = 0;                % Koefisien Adveksi arah y
% Kasus 2
Vx = -0.159*10^(-8);
Vy = -0.159*10^(-8);
% Nilai Konstanta Skema Beda Hingga
Ax = Vx/Delx;
Ay = Vy/Dely;
Bx = Dx/(Delx^2);
By = Dy/(Dely^2);
Ax2 = Ax/2.;
Ay2 = Ay/2.;
% Pembagi Skema Beda Hingga
Denom1=2.*Bx+2*By;      % Untuk Kode 1
Denom2=-Ay+2.*Bx-By;    % Untuk Kode 2
Denom3=Ax-Bx+2.*By;     % Untuk Kode 3
Denom4=Ay+2.*Bx-By;     % Untuk Kode 4
Denom5=-Ax-Bx+2.*By;    % Untuk Kode 5
Denom6=-Ax-Ay-Bx-By;    % Untuk Kode 6
Denom7=Ax-Ay-Bx-By;     % Untuk Kode 7
Denom8=-Ax+Ay-Bx-By;    % Untuk Kode 8
Denom9=Ax+Ay-Bx-By;     % Untuk Kode 9

% Pemisalan Nilai Awal Grid
for i = 1:Nx
 for j = 1:Ny
```

```
   if CD(i,j) ~= 0
    CA(i,j) = 1;
   end
  end
end

% Pembagian antara Daratan dan Perairan
for i = 1:Nx
 Rub(i) = 1;
 for j = 2:Ny
  if CA(i,j)-CA(i,j-1) ~= 0
   Rub(i) = Rub(i)+1;
  end
 end
end

% Perhitungan Jumlah Grid yang dibagi antara Daratan dan Perairan
for i = 1:Nx
 r = 1;
 Nilai = 1;
 for j = 2:Ny
  if CA(i,j)-CA(i,j-1) == 0
   Nilai = Nilai+1;
   CDR(i,r) = Nilai;
  else
   r = r+1;
   Nilai = 1;
  end
 end
end

% Modifikasi Jumlah Grid di Daratan dan Perairan
for i=22:30
 CDR(i,3)=1;
end
for i=24:30
 CDR(i,5)=0;
end
CDR(20,5)=0;
CDR(21,5)=0;
CDR(23,7)=0;
CDR(24,7)=0;
CDR(31,3)=0;
CDR(32,3)=0;

TTP = 0;
for i = 1:Nx
 has = 0;
 for j = 1:Ny
  if CD(i,j) ~= 0
   has = has+1;
  end
 end
 CDP(i) = has;     % Total Jumlah Grid di Perairan
 if i == 1
  CDK(i) = CDP(i);
 else
  CDK(i) = CDK(i-1)+CDP(i);
```

```
 end
 TTP = TTP+has;     % Jumlah Solusi di Dalam Matriks
end

% Nilai Awal Konsentrasi pada Masing Masing Statiun
Robin(1:TTP)=0.;

% Logam Arsen
Robin(1039)=0.011;      % St1
Robin(1092)=0.011;
Robin(1145)=0.011;
Robin(1197)=0.011;
Robin(1249)=0.011;
Robin(2653)=0.385;      % St2
Robin(2654)=0.385;
Robin(2655)=0.385;
Robin(2656)=0.385;
Robin(2657)=0.385;
Robin(2658)=0.385;
Robin(933)=0.454;       % St3
Robin(986)=0.454;
Robin(1040)=0.454;
Robin(1093)=0.454;
Robin(1)=0.463;         % St4
Robin(2)=0.463;
Robin(3)=0.463;
Robin(689)=0.48;        % St5

% Logam Krom
Robin(1039)=2.02;       % St1
Robin(1092)=2.02;
Robin(1145)=2.02;
Robin(1197)=2.02;
Robin(1249)=2.02;
Robin(2653)=10^(-8);    % St2
Robin(2654)=10^(-8);
Robin(2655)=10^(-8);
Robin(2656)=10^(-8);
Robin(2657)=10^(-8);
Robin(2658)=10^(-8);
Robin(933)=10^(-8);     % St3
Robin(986)=10^(-8);
Robin(1040)=10^(-8);
Robin(1093)=10^(-8);
Robin(1)=10^(-8);       % St4
Robin(2)=10^(-8);
Robin(3)=10^(-8);
Robin(689)=10^(-8);     % St5

% Logam Timbal
Robin(1039)=6.1;        % St1
Robin(1092)=6.1;
Robin(1145)=6.1;
Robin(1197)=6.1;
Robin(1249)=6.1;
Robin(2653)=5.53;      % St2
Robin(2654)=5.53;
Robin(2655)=5.53;
```

```
Robin(2656)=5.53;
Robin(2657)=5.53;
Robin(2658)=5.53;
Robin(933)=0.24;      % St3
Robin(986)=0.24;
Robin(1040)=0.24;
Robin(1093)=0.24;
Robin(1)=0.46;        % St4
Robin(2)=0.46;
Robin(3)=0.46;
Robin(689)=7.2;       % St5

TBC=0;
for i=1:TTP
    if Robin(i)~=0
        TBC=TBC+1;    % Banyaknya Nilai Awal
    end
end

% Menyusun Matriks AX=B dimana A = MA(TTP,TTP), X = MX(TTP), dan B
= MB(TTP)
% Dengan Nilai awal Matriksnya 0
MA(1:TTP,1:TTP)=0.0;
MBB(1:TTP-TBC)=0;
MAA(1:TTP-TBC,1:TTP-TBC)=0;

% Menghitung Nilai pada Matriks A
% Skema Beda Hingga Adveksi Difusi 2-Dimensi
k=0;
for i = 1:Nx
 for j = 1:Ny
  if CD(i,j)~=0
  k=k+1;
  pilih=CD(i,j);
  switch pilih
   case 1  %Kode Grid 1 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(By-Ay2)/Denom1;
    MA(k,k-1)=-(By+Ay2)/Denom1;
    if Rub(i-1)<=3
     MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Bx+Ax2)/Denom1;
     MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(Bx-Ax2)/Denom1;
    else
     if j<=30
      MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Bx+Ax2)/Denom1;
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(Bx-Ax2)/Denom1;
     else
      if Rub(i)<=3
       MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1)-CDR(i-1,3))=-
(Bx+Ax2)/Denom1;
       MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(Bx-Ax2)/Denom1;
      elseif Rub(i+1)<=3
       MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Bx+Ax2)/Denom1;
       MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3))=-(Bx-
Ax2)/Denom1;
      else
       if j<=42
        MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Bx+Ax2)/Denom1;
```

```
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(Bx-Ax2)/Denom1;
       elseif i>=25
        MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Bx+Ax2)/Denom1;
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(Bx-Ax2)/Denom1;
       else
        MA(k,k+CDR(i,1)-CDR(i-1,1)-CDR(i-1,3)-CDR(i-1,5)-CDP(i-
1)+CDR(i,3)+CDR(i,5))=-(Bx+Ax2)/Denom1;
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)+CDR(i,5)-
CDR(i+1,3)-CDR(i+1,5))=-(Bx-Ax2)/Denom1;
       end
      end
     end
    end
   case 2  %Kode Grid 2 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(-Ay-2.*By)/Denom2;
    MA(k,k+2)=-By/Denom2;
    if Rub(i)<=3
     MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax2+Bx)/Denom2;
     MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax2+Bx)/Denom2;
    else
     if Rub(i+1)<=3
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3))=-(-
Ax2+Bx)/Denom2;
     else
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax2+Bx)/Denom2;
     end
      MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax2+Bx)/Denom2;
    end
   case 3  %Kode Grid 3 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(-Ay2+By)/Denom3;
    MA(k,k-1)=-(Ay2+By)/Denom3;
    MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax-2.*Bx)/Denom3;
    MA(k,k+CDR(i,1)-CDP(i-1)-CDR(i-2,1)-CDP(i-2))=-Bx/Denom3;
   case 4  %Kode Grid 4 FIX
    MA(k,k)=1.;
    MA(k,k-1)=-(Ay-2.*By)/Denom4;
    MA(k,k-2)=-By/Denom4;
    if Rub(i)<=3
     if Rub(i-1)<=3
      MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax2+Bx)/Denom4;
     else
      MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1)-CDR(i-1,3))=-
(Ax2+Bx)/Denom4;
     end
    else
     MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax2+Bx)/Denom4;
    end
    MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax2+Bx)/Denom4;
   case 5  %Kode Grid 5 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(-Ay2+By)/Denom5;
    MA(k,k-1)=-(Ay2+By)/Denom5;
    if Rub(i)<=3
     MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom5;
     MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom5;
    else
     if j<=42
```

```
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom5;
      MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom5;
     else
      if Rub(i)<6
       if Rub(i+1)<6
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3))=-(-
Ax-2.*Bx)/Denom5;
       else
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3)-
CDR(i+1,5))=-(-Ax-2.*Bx)/Denom5;
       end
        MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)-
CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom5;
      else
       MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)+CDR(i,5)-
CDR(i+1,3)-CDR(i+1,5))=-(-Ax-2.*Bx)/Denom5;
       MA(k,k+CDR(i,1)-
CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)+CDR(i,5)-CDR(i+2,3)-
CDR(i+2,5))=-Bx/Denom5;
      end
     end
    end
   case 6  %Kode Grid 6 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(-Ay-2.*By)/Denom6;
    MA(k,k+2)=-By/Denom6;
    if Rub(i)<=3
     MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom6;
     MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom6;
    else
     if j<=35
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom6;
      MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom6;
     else
      if Rub(i)<6
       if Rub(i+1)<6
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3))=-(-
Ax-2.*Bx)/Denom6;
       else
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3)-
CDR(i+1,5))=-(-Ax-2.*Bx)/Denom6;
       end
       MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)-
CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom6;
      else
       MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)+CDR(i,5)-
CDR(i+1,3)-CDR(i+1,5))=-(-Ax-2.*Bx)/Denom6;
       MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)+
CDR(i,5)-CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom6;
      end
     end
    end
   case 7  %Kode Grid 7 FIX
    MA(k,k)=1.;
    MA(k,k+1)=-(-Ay-2.*By)/Denom7;
    MA(k,k+2)=-By/Denom7;
    MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax-2.*Bx)/Denom7;
    MA(k,k+CDR(i,1)-CDP(i-1)-CDR(i-2,1)-CDP(i-2))=-Bx/Denom7;
   case 8  %Kode Grid 8 FIX
```

```
    MA(k,k)=1.;
    MA(k,k-1)=-(Ay-2.*By)/Denom8;
    MA(k,k-2)=-By/Denom8;
    if Rub(i)<=3
     MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom8;
     MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom8;
    else
     if j<=35
      MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i))=-(-Ax-2.*Bx)/Denom8;
      MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1))=-Bx/Denom8;
     else
      if Rub(i)<6
       if Rub(i+1)>5
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3)-
CDR(i+1,5))=-(-Ax-2.*Bx)/Denom8;
        MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)-
CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom8;
       elseif Rub(i+1)<=3
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3))=-(-Ax-
2.*Bx)/Denom8;
        MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3))=-
Bx/Denom8;
       else
        MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)-CDR(i+1,3))=-(-
Ax-2.*Bx)/Denom8;
        MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)-
CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom8;
       end
      else
       MA(k,k+CDR(i,1)-CDR(i+1,1)+CDP(i)+CDR(i,3)+CDR(i,5)-
CDR(i+1,3)-CDR(i+1,5))=-(-Ax-2.*Bx)/Denom8;
       MA(k,k+CDR(i,1)-CDR(i+2,1)+CDP(i)+CDP(i+1)+CDR(i,3)+
CDR(i,5)-CDR(i+2,3)-CDR(i+2,5))=-Bx/Denom8;
      end
     end
    end
   case 9  %Kode Grid 9 FIX
    MA(k,k)=1.;
    MA(k,k-1)=-(Ay-2.*By)/Denom9;
    MA(k,k-2)=-By/Denom9;
    MA(k,k+CDR(i,1)-CDR(i-1,1)-CDP(i-1))=-(Ax-2.*Bx)/Denom9;
    MA(k,k+CDR(i,1)-CDR(i-2,1)-CDP(i-1)-CDP(i-2))=-Bx/Denom9;
   end
  end
 end
end

k=0;
for i=1:TTP
 if Robin(i)~=0
  k=k+1;
 else
  l=0;
  for j=1:TTP
   if Robin(j)~=0
    l=l+1;
    MBB(i-k)=MBB(i-k)-MA(i,j)*Robin(j); % Matriks MB tanpa Nilai
Konsentrasi Awal
   else
```

```
    MAA(i-k,j-l)=MA(i,j);                % Matriks MA tanpa Nilai
Konsentrasi Awal
   end
  end
 end
end

% Menghitung Nilai Matriks MX
MXX=pinv(MAA)*MBB';                                   % Matriks MX
tanpa Nilai Konsentrasi Awal
j=0;
for i=1:TTP
 if Robin(i)~=0
  j=j+1;
  MX(i)=Robin(i);
 else
  MX(i)=MXX(i-j);
 end
end

% Mengembalikan Nilai ke dalam Matriks Danau Unhas
k=0;
for i = 1:Nx
 for j = 1:Ny
  if CD(i,j)~= 0
   k=k+1;
   C(i,j)=MX(k);
  else
   C(i,j)=NaN;
  end
 end
end

% Membuat Plot
[X,Y] = meshgrid(1:Nx,1:Ny);
Z(:,:)=C(1:Nx,1:Ny);

% Plot dalam bentu 2-Dimensi
figure(1),
contourf(X,Y,Z',300,'linestyle','none');
set(gcf,'color','w');

% Lokasi teks stasiun
annotation('textbox',[0.400066408701109 0.849231950844855
0.0695764484417484 0.054761904761905],'String',{'St
1'},'FitBoxToText','off','BackgroundColor',[1 1 1]);
annotation('textbox',[0.696345952729553 0.375268817204301
0.0695764484417484 0.054761904761905],'String',{'St
2'},'FitBoxToText','off','BackgroundColor',[1 1 1]);
annotation('textbox',[0.358838109182179 0.252073732718895
0.0695764484417484 0.054761904761905],'String',{'St
3'},'FitBoxToText','off','BackgroundColor',[1 1 1]);
annotation('textbox',[0.152691382555951 0.228801843317972
0.0695764484417484 0.054761904761905],'String',{'St
4'},'FitBoxToText','off','BackgroundColor',[1 1 1]);
annotation('textbox',[0.383715226939971 0.455760368663595
0.0695764484417484 0.054761904761905],'String',{'St
5'},'FitBoxToText','off','BackgroundColor',[1 1 1]);
```

```
hold on
xlabel('\it\bf Lebar Danau','fontsize',12,'Color','b');
ylabel('\it\bf Panjang Danau','fontsize',12,'Color','b');
caxis([0 max(MX)]);
hold off

% Plot dalam bentuk 3-Dimensi
figure(2),
ZZ(:,:)=C(1:Nx,1:Ny);
surf(X,Y,ZZ','linestyle','none');
axis ([1 Nx 1 Ny 0 100]);
set(gcf,'color','w');
caxis([0 max(MX)]);

% Mengatur label axis 3-Dimensi
xlabel('\it\bf Lebar Danau','fontsize',12,'Color','b');
xh = get(gca,'XLabel');
set(xh, 'Units', 'Normalized');
pos = get(xh, 'Position');
set(xh, 'Position', pos.*[1,0,1],'Rotation',20);
ylabel('\it\bf Panjang Danau','fontsize',12,'Color','b');
yh = get(gca,'YLabel');
set(yh, 'Units', 'Normalized');
pos = get(yh, 'Position');
set(yh, 'Position', pos.*[1,-1,1],'Rotation',-30);
zlabel('\it\bf Konsentrasi Polutan','fontsize',12,'Color','b');
zh = get(gca,'ZLabel');
set(zh, 'Units', 'Normalized');
pos = get(zh, 'Position');
set(zh, 'Position', pos.*[1,1,1],'Rotation',90);
```