In [39]:
```
import numpy as np
import pandas as pd
import xarray as xr
from matplotlib import pyplot as plt
%matplotlib inline
```

In [40]:
```
# 4.1
# Load a csv file, and clean possible data points with missing values.
df4 = pd.read_csv("Water level impact on As release.csv",
                  usecols=range(21),
                  skiprows=[1],
                  na_values=["n.a.", "NO3-"])
df4.head(24)
```

Out[40]:

	Site	Year	Month	Death	pH	T	EC*	ORP*	Water level	NH4+	...	Mg	Ca	Fe	Fe2+	Mn	NO3-	Cl	DOC	SO42-	As
0	NH03A	2013	10	10	6.7	20.8	1321	-123.9	21.41	2.1	...	38.6	164.1	22.4	14.9	38.6	0.0	25.0	31.2	0.0	22.5
1	NH03A	2013	12	10	6.6	19.1	1244	-133.5	21.16	7.4	...	33.8	174.3	25.9	21.7	33.8	0.0	42.6	5.4	4.6	59.1
2	NH03A	2014	1	10	6.9	17.5	1185	-111.1	21.09	2.5	...	39.6	188.5	17.6	7.6	39.6	0.3	30.5	7.0	4.3	17.6
3	NH03A	2014	2	10	7.1	16.8	1112	-21.2	21.66	2.5	...	42.6	196.2	0.8	0.2	42.6	0.2	26.8	17.6	4.5	2.2
4	NH03A	2014	3	10	7.2	16.9	1256	-49.4	21.67	2.4	...	38.0	186.2	3.6	2.1	38.0	0.6	28.8	2.9	4.6	3.0
5	NH03A	2014	4	10	6.9	18.7	1175	-104.6	21.97	2.4	...	39.9	162.7	11.5	11.4	39.9	0.0	29.3	7.6	0.0	10.2
6	NH03A	2014	5	10	6.9	20.3	797	-139.2	21.90	2.1	...	36.6	152.1	17.8	11.7	36.6	0.0	29.1	4.9	0.0	17.4
7	NH03A	2014	6	10	6.9	19.9	1284	-127.2	21.37	2.6	...	23.9	183.0	17.0	12.9	23.9	0.0	31.1	14.2	0.0	14.5
8	NH03A	2014	7	10	6.8	21.0	1310	-131.2	21.53	2.5	...	23.1	175.4	20.5	13.3	23.1	0.0	38.5	1.3	4.7	39.0
9	NH03A	2014	8	10	6.9	22.6	1316	-110.6	21.70	2.4	...	23.1	175.0	23.8	11.9	23.1	0.0	43.1	6.8	4.9	31.9
10	NH03A	2014	9	10	6.8	19.4	1330	-99.6	21.87	2.6	...	22.3	172.1	18.4	10.9	22.3	0.0	37.2	5.9	4.6	25.7
11	NH03A	2014	10	10	6.9	19.4	1307	-101.4	21.56	1.3	...	23.5	180.6	17.3	11.3	23.5	0.5	36.0	7.2	5.1	21.3
12	NH03B	2013	10	25	7.3	20.3	651	-167.8	21.20	2.1	...	26.0	113.7	7.3	6.5	6.5	0.0	5.7	22.7	4.9	1030.0
13	NH03B	2013	12	25	7.1	18.6	880	-166.8	20.83	7.4	...	25.2	120.8	8.0	7.3	8.0	0.0	5.6	1.9	4.4	1030.0
14	NH03B	2014	1	25	7.2	17.8	806	-168.9	20.58	2.5	...	31.9	151.5	8.8	6.7	9.6	0.0	5.0	2.6	4.6	1020.0
15	NH03B	2014	2	25	7.5	16.9	834	-143.2	20.47	2.5	...	28.2	133.8	8.3	4.8	8.1	0.0	5.5	4.1	4.7	994.0
16	NH03B	2014	3	25	7.4	16.5	867	-149.7	20.50	2.4	...	25.4	129.5	3.2	3.1	8.5	0.0	5.0	6.2	0.0	159.0
17	NH03B	2014	4	25	7.3	18.9	750	-139.8	20.51	2.4	...	26.9	114.2	5.8	3.7	8.7	0.0	3.9	3.8	7.2	689.0
18	NH03B	2014	5	25	7.4	20.6	637	-169.2	20.71	2.1	...	24.7	105.4	6.5	6.0	8.0	0.0	4.0	6.4	6.4	656.0
19	NH03B	2014	6	25	7.4	20.1	870	-177.8	20.72	2.6	...	18.1	129.2	6.6	5.6	7.5	0.1	5.1	3.3	4.1	901.0

	Site	Year	Month	Death	pH	T	EC*	ORP*	Water level	NH4+	...	Mg	Ca	Fe	Fe2+	Mn	NO3-	Cl	DOC	SO42-	As
20	NH03B	2014	7	25	7.3	22.2	884	-188.1	20.89	2.5	...	16.8	123.5	6.6	6.6	7.4	0.3	5.1	0.8	4.3	1040.0
21	NH03B	2014	8	25	7.4	21.8	900	-177.3	20.99	2.4	...	17.8	125.8	6.6	6.5	7.5	0.0	5.3	4.4	4.1	1050.0
22	NH03B	2014	9	25	7.2	19.7	887	-115.8	21.31	2.6	...	17.4	122.5	4.9	4.9	7.5	0.0	4.9	3.2	3.8	982.0
23	NH03B	2014	10	25	7.3	19.5	879	-113.1	21.29	1.3	...	19.2	130.0	6.5	6.4	8.7	0.0	1.3	4.9	0.0	1030.0

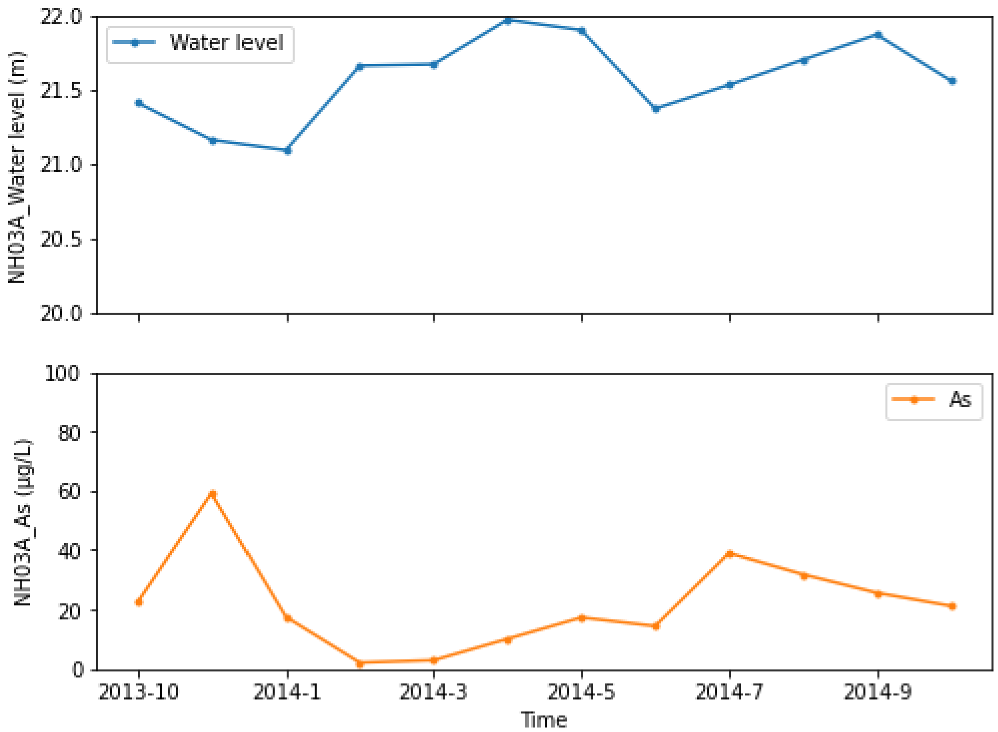
24 rows × 21 columns

In [41]:

```
# 4.2
# Add a new column"Time"
df4["Time"]=df4["Year"].astype(str)+"-"+df4["Month"].astype(str)
# Choose data based on "Site", and create df4_1 and df4_2 for Site NH03A and Site NH03B.
df4_1=df4.loc[df4["Site"]=="NH03A"]
df4_2=df4.loc[df4["Site"]=="NH03B"]
```

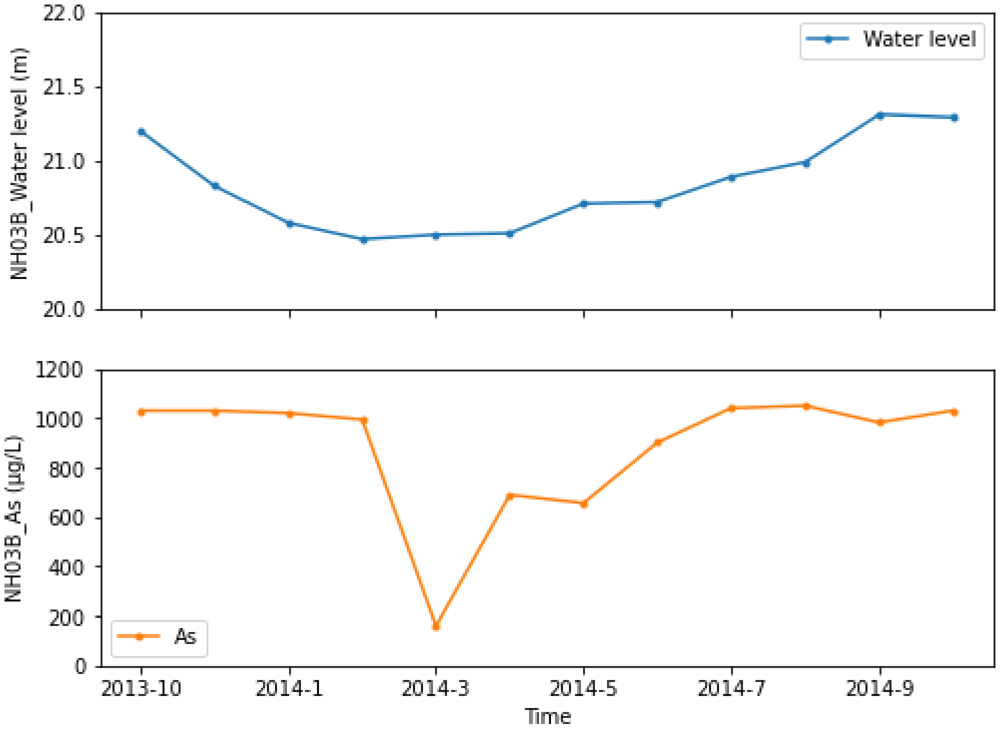
In [42]:
```
# 4.2 Connected above
# Set the column"Time" as the index for plotting
df4_1 = df4_1.set_index("Time")
# Choose 2 Variables("Water level"&"As")to plot the time series for Site NH03A, which is 10 meters below the ground surface.
cols_plot = ["Water level","As"]
axes = df4_1[cols_plot].plot(marker=".", linestyle="solid", figsize=(8, 6), subplots=True)
axes[0].set_ylabel("NH03A_Water level (m)")
axes[0].set_ylim(20.00,22.00)
axes[1].set_ylabel("NH03A_As (μg/L)")
axes[1].set_ylim(0,100)
```

Out[42]: (0.0, 100.0)



In [43]:
```
# 4.2 Connected above
df4_2 = df4_2.set_index("Time")
# Do the same operations for Site NH03B,which is 25 meters below the ground surface.
axes2 = df4_2[cols_plot].plot(marker=".", linestyle="solid", figsize=(8, 6), subplots=True)
axes2[0].set_ylabel("NH03B_Water level (m)")
axes2[0].set_ylim(20.00,22.00)
axes2[1].set_ylabel("NH03B_As (μg/L)")
axes2[1].set_ylim(0,1200)
```

Out[43]: (0.0, 1200.0)



In [44]:
```python
# 4.3
# Calculate the As average of the whole Year
As_NH03A_mean=round(df4_1["As"].mean(),2)
As_NH03B_mean=round(df4_2["As"].mean(),2)
print("As_NH03A_mean is ",As_NH03A_mean,"μg/L.")
print("As_NH03B_mean is ",As_NH03B_mean,"μg/L.")
# Calculate the As average of different Seasons
As_NH03A_Spring=round(df4_1["As"][(df4_1["Month"]>=3)&(df4_1["Month"]<=5)].mean(),2)
As_NH03A_Summer=round(df4_1["As"][(df4_1["Month"]>=6)&(df4_1["Month"]<=8)].mean(),2)
As_NH03A_Fall=round(df4_1["As"][(df4_1["Month"]>=9)&(df4_1["Month"]<=11)].mean(),2)
As_NH03A_Winter=round(df4_1["As"][(df4_1["Month"]==12)|(df4_1["Month"]==1)|(df4_1["Month"]==2)].mean(),2)
print("As_NH03A_Spring:",As_NH03A_Spring,"; As_NH03A_Summer:",As_NH03A_Summer)
print("As_NH03A_Fall:",As_NH03A_Fall,"; As_NH03A_Winter:",As_NH03A_Winter)
As_NH03B_Spring=round(df4_2["As"][(df4_2["Month"]>=3)&(df4_2["Month"]<=5)].mean(),2)
As_NH03B_Summer=round(df4_2["As"][(df4_2["Month"]>=6)&(df4_2["Month"]<=8)].mean(),2)
As_NH03B_Fall=round(df4_2["As"][(df4_2["Month"]>=9)&(df4_2["Month"]<=11)].mean(),2)
As_NH03B_Winter=round(df4_2["As"][(df4_2["Month"]==12)|(df4_2["Month"]==1)|(df4_1["Month"]==2)].mean(),2)
print("As_NH03B_Spring:",As_NH03B_Spring,"; As_NH03B_Summer:",As_NH03B_Summer)
print("As_NH03B_Fall:",As_NH03B_Fall,"; As_NH03B_Winter:",As_NH03B_Winter,)
# From the output below, it is obvious that groundwater of Site NH03B(25m) has much higher As concentration than
# that of Site NH03A(10m), related to the REDOX conditions.
# For a certain site, As concentration in Spring seems to be much lower than in the other seasons,
# which may be attributed to the water level changes. From Figure4.2, for deeper aquifers(e.g.NH03B(25m)),
# lower the water level is, lower the As concentration, while the shallower aqufers(e.g.NH03A(10m))
# reacts to the water level change more moderately.
```

```
As_NH03A_mean is  22.03 μg/L.
As_NH03B_mean is  881.75 μg/L.
As_NH03A_Spring: 10.2 ; As_NH03A_Summer: 28.47
As_NH03A_Fall: 23.17 ; As_NH03A_Winter: 26.3
As_NH03B_Spring: 501.33 ; As_NH03B_Summer: 997.0
As_NH03B_Fall: 1014.0 ; As_NH03B_Winter: 1014.67
```