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Original Paper

Interactions of physico-chemical properties of the River Nile water and fungal diversity in River Nile streams in Delta region

Ahmed M. Abdel-Raheem, Gamalat A. Abd-Elaah, Osman M. El-Maghraby and Mahmoud S. Bakhit
Botany department, Faculty of Science, Sohag University.

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Abstract
Water pollution in Egypt is increasing over time, with constant supply of pollutant effluents to the water system from several sources. Water samples were collected for hydrochemicalanalysis during four successive seasons from some irrigation canals and streams of River Nile in Delta region governorates.There are various correlations patterns between fungal communities and physico-chemical parameters.Air and water temperature weremajor factors that affect fungal distribution. Calcium and magnesium have inverse correlation on fungal diversity. There was no significant correlation of SO_4^{2-} andNO_2^- with distribution of freshwater fungi. Ammonia and phosphate encouraged fungal growth.Salinity played active role in determining fungal diversity and community composition. Changes in species composition were correlated positively with elevated concentrations of NH_3^+, and pHin some governorates.

Key word: Physico-chemical, populations, Nile delta, Freshwater fungi.

Introduction:

Fungi may be exposed to a wide variety of organic and inorganic pollutants in the environment. Pollutants may exhibit toxicity and cause changes in fungal community composition (Gadd 2007). The effect of pollutants on fungal population community size and composition is particularly difficult to assess. Environmental pollution might be expected to lead to both toxic (destructive) and enrichment disturbance on fungal populations (Wainwright 1988). The resultant degree of toxic disturbance will depend upon both toxicant concentration and its availability to the fungal population, as well as to the susceptibility of the individuals involved. Toxicants may be have a selectivelyeffect on a few fungal species, or amore generalized effect.

Freshwater fungi are considered a cosmopolitan and a diverse group (McLaughlin *et al.,* 2001). Lignicolous freshwater fungi grow on submerged woody debris in freshwater streams, ponds and lakes (Goh and Hyde 1996, Wong *et al.,* 1998). Lignicolous freshwater fungi play an important role in the decomposition of submerged wood by breaking down lignocelluloses and releasing nutrients whichare important in ecosystem functioning (Yuen *et al.,* 1998, Bucher *et al.,* 2004, Hyde *et al.,* 2016).

Several studies reported the effect of pollutants on freshwater fungal communities (Tan and Lim 1984; Maltby and Booth 1991; Au *et al.,* 1992; Bärlocher 1992a; Tsui *et al.,* 2001; Luo *et al.,* 2004). The fungal community structure greatly differs with the physico-chemical properties of the respective habitats, such as water flow (PatteeandChergui 1995; Baldy *et al.,* 2002), nutrient concentrations (Gulis *et al.,* 2004; Rankovic 2005), salinity (Hyde and Lee1995; Roache *et al.,* 2006), temperature (Bärlocher *et al.,* 2008; Raja *et al.,* 2009) and depth (Wurzbacher *et al.,* 2010). The ability of fungi to survive in the presence of potentially toxic metals depends on a number of biochemical and structural properties, including physiological and/or genetically adaptation (Gadd 2000, 2007) .In general terms, toxic metals may affect fungal populations by reducing abundance and species diversity (Babich and Stotzky 1985; Arnebrant *et al*., 1987).

Water pollution in Egypt is increasing over time, with constant supply ofpollutant effluents to the water system from several sources. One of the major sources is the disposal of untreated or semi-treated domestic wastes into water bodies. The low level of sanitation service especially in rural areasmakes nearby streams (either canals or drains) the perfect places for inhabitants to dispose their sewage. Moreover, the excessive use of fertilizers and pesticides is another major source of water pollution. The effect of agricultural pollution was increased due to the extensive drainage reuse within the Nile Delta. Several studies revealed that untreated industrial wastes of more than 350 factories were discharged directly into the Nile and the Mediterranean Sea, most of them released explicitly known toxic and hazardous chemicals such as detergents, heavy metals and pesticides (RNPD 1989).

Materials and Methods:

Water samples were collected in clean one-liter polyethylene bottles for hydrochemicalanalysis during four successive seasons from irrigation canals and the River Nilein Delta region, during the period between February 2010 and December 2011.

Submerged, dead woody debris were collected randomly from irrigation canals and the River Nile, four times over 2 years. Sampling times included the four seasons (winter, summer, spring, and autumn) in the eight governorates (Dakahlya, Sharqiyah, Qalyubiya, Kafr El-Sheikh, El-Behera, Gharbeyia, Menofya and Damietta) within the Nile Delta region.

Chemical analysis of the collected water samples was carried out according to the standard methods (Rainwater *et al.*, 1960; Booth 1983). Fungal species richness, number of fungal collections per sample and number of records for each taxonomic group in the studied governorate and season collection were calculated. Canonical Correlation Analysis (CCA) was employed to test if variation in community composition is explained by physicho-chemical parameters.

Hydrochemical analysis:

Air and water temperature at each site were measured *insitu* using Celsius-thermometer. Potential of Hydrogen (pH) values of water samples were measured using a digital pH meter (HANNA pH 211 microprocessor pH meters).

Electrical conductivity (ECμs/cm) of water samples was measured using EC meter (model: HANNA HI 99300 Conductivity meter). Salinity, total dissolved solids (TDS) in mg/l were measured for each sample using (HANNA HI 99300 Conductivity meter).Alkalinity was determined by titration using phenolphthalein and methyl orange indicators.

Chloride (Cl^-) anion content was determined by volumetrically titration against silver nitrate using potassium chromate (K_2CrO_4) as an indicator.Hardness was determined by titration of Erichrome black T indicator and standard (0.01 N) Ethylenediaminetetraacetic acid (EDTA) solution. Calcium (Ca^{2+}) and Magnesium (Mg^{2+})cations content of water samples were determined by complexometric titration using EDTA solution and Eriochrome black T as indicator. Calcium was determined using (muroxide) indicator in presence of sodium hydroxide, while magnesium cation was calculated by subtracting the calcium value from (Ca^{2+} and Mg^{2+}) value after their determination using Eriochrome black T.

Sulphate (SO_4^{2-}) was determined in water samples by the turbidimetric method. It is based upon the fact that barium sulphate tends to precipitate in a colloidal form. The absorbance of the barium sulphate solution is measured by turbidimeter and the sulphate ion concentration, determined by comparison of the reading with a standard curve.Ammonia (NH_3) concentration was determined in water samples using phenate method. Ammonia reacts with alkaline phenol and hypochlorite to form indophenol blue that is proportional to the ammonia concentration. The blue color is intensified with sodium nitroprusside to form a colored complex that absorbs at 660 nm. Concentration of ammonia is determined by comparison of absorbance signal with calibration results obtained from prepared standards of varying concentrations (APHA 2005).

Phosohate (PO_4^{3-}) anion concentration was determined colorimetrically using UV/visible spectrophotometer, at wavelength 700 nm, using molybdate reagent and Tin chloride ($SnCl_2$) as indicator.

Nitrite (NO_2^-) ion was determined by reaction of nitrite ions with sulfanylamide in acidic medium and the diazo compound obtained further reacts with diamine yielding in an azo color. The nitrite ion concentration is determined by measuring the absorbance of the azo color at 540-545 nm by spectrophotometer.

Statistical analysis: Variation in averages of physico-chemical parameters and fungi distribution among tested governorateswasanalysed using PAST softwareversion 2.11 (Hammer *et al.,* 2001). Canonical correspondence analysis (CCA) included data of 218 fungal taxa and11 environmental parameters across 8 sampling governorates during 4 season's period was applied to evaluate role ofenvironmental variables in fungal communities.

Results:

Physical and chemical parameters varied between sites, governorates and seasons. Interaction between physico-chemical properties and diversity of freshwater fungi was strongly observed. The minimum, maximum and average values of hydrochemical analysis of the collected water sampleswere listed in table 1. The patterns of their variations along the studied area and during study period are illustrated in figs. 1 to 7.

Physico-chemical characteristics of River Nile water:

The air temperature ranged between 16 and 44 ^{0}Cduring the studied period. The maximum air temperature, 44 ^{0}C, was recorded in August 2010 while the minimum temperature was recorded in December 2011 (Table 1). The water temperature ranged from 10 to 29 ^{0}C. The highest water temperature was 29 ^{0}C in August 2010 while the lowest was 10 ^{0}C in December 2011(Table 1).Potential of Hydrogen (pH) values ranged from 6 to 6.8 in the present study (Table 2).

Total dissolved salts(TDS) content of water samples were fluctuated between 227 ppm and614 ppm. The highest values of TDS were reported inKafr El-Sheikh (375), Damietta (328) and Sharqiyah (313) governorates, whereas the lowest ones occurred in Gharbeyia and Menofya governorates(Tables 1, 2 and Figure 1).

Electrical conductivity (EC) values exhibited great variationsbetween the different governorates and seasons and were fluctuated between 324 µs/cm and 932 µs/cm in the different sites in Nile Delta region. The highest averages of EC were reported fromKafr El-Sheikh (583), Sharqiyah (529) and Menofya (502). Alkalinity of studied streams and irrigation canals in the different four seasons was ranged between 88and 320mg/L. Kafr El-Sheikh and El Behera governorates had the highest values of alkalinity (Table 1).

Chloride concentrations ranged between 15and 90ppm (Table 1). The highest values of chloride concentration were reported in Menofya and Qalyubiya governorates. In August 2010 collection (28-90ppm) whilethe lowest values in February 2010 (15-23ppm). Calcium and magnesium concentrations ranged between 25 and 57.5ppm, 13.8and 31.8 ppm,respectively. The average values of calcium and magnesium concentrations showednarrowdifferences between governorates and seasons collections. Nitrite concentration in water samples was fluctuated between 0.015 and 0.15 ppm while, Ammonia concentrations ranged between 0.01 and 1.76ppm in the studied sites as shown in Table (1). Sulphateion concentrations ranged between 19.6 and 46 ppm. Meanwhile phosphate was in the range from 0.001 to 0.39 ppm (Table 1). The values of the physical and chemical parameters of the different seasons and governorates were listedin tables2 and 3.

Some physico-chemical parameters exhibited strong peak in some studied governorates or seasons. For example, NH_3^+andCl$^-$concentration werevery high in Menofya and Qalyubiya governorates and August collection, TDS peaked in KafrEl-Sheikh and Damietta and also Ca $^{2+}$peakedin KafrEl-Sheikh.

	February 2010 collection														
Site	**Physical properties**					**Chemical properties**								**Fungal population**	
	A.T 0C	**W.T 0C**	**pH**	**TDS ppm**	**EC µS/cm**	**Alkalinity mg/L**	**Cl^- ppm**	**Ca^{2+} ppm**	**Mg^{2+} ppm**	**SO_4^{2-} ppm**	**NO_2^- ppm**	**NH_3 ppm**	**PO_4^{3-} ppm**	**S.R**	**NRS**
Dakahlya	**Min. temperature (8 -18) Max. emperature (16-34)**	**16-18**	7.5	307.75	479.3	161.3	16.5	39.25	17	31.49	0.024	0.33	0.22	42	0.67
Sharqiyah			6.9	227	442	130	15	34	15.4	35.8	0.009	0.023	0.09	31	1.12
Qalyubiya			6.5	393.75	626.5	206.5	23.25	52.25	22.75	36.87	0.022	0.97	0.32	43	0.90
Kafr El-Sheikh			6.6	281	480	104	17	32	19.2	29.7	0.032	0.037	0.12	20	0.90
El Behera			6.7	408.5	650	247	22.5	52	22	40.5	0.041	0.46	0.06	23	0.82
Gharbeyia			7.4	258	411.5	126.5	14.5	33	18	30.5	0.0015	0.045	0.015	30	0.73
Menofya			6.9	280	446	88	15	36	27	32	0.003	0.6	0.11	24	1.24
Damietta			6.8	310	498	112	19	40	22	33	0.044	0.04	0.07	20	0.95
Average			6.9	308.25	504.16	146.91	17.84	39.81	20.42	33.73	0.02	0.31	0.13	29	0.92
Range			6. 5 -7.5	227-408	411-650	88-247	15-23	32-52	15-27	29.7-40.5	.0015-.044	.023-0.97	.015-.32	20-43	0.67-1.24
			August 2010 collection												
Dakahlya	**Min. temperature (20 - 28) Max. temperature (32 -44)**	**27-29**	6.5	255.8	388.7	192.3	23.0	37.0	21.0	25.5	0.05	1.05	0.15	58	1.07
Sharqiyah			6.1	463.7	703.67	247.7	45.0	50.33	27.13	35.9	0.03	0.92	0.07	37	1.02
Qalyubiya			6.6	274.7	434	185.7	55.67	45.13	20.37	31.13	0.08	1.31	0.21	39	0.83
Kafr El-Sheikh			6.3	614.5	932.0	320.0	48.0	57.5	31.8	19.85	0.08	0.88	0.39	38	1.27
El Behera			6.3	267	406	178	38	38	19	23	0.037	1.27	0.2	24	1.22
Gharbeyia			6.2	237.5	360.5	137.5	31.5	29.0	19.5	35.5	0.07	1.76	0.02	44	1.12
Menofya			6	303	460	105	90	40	16.8	22.5	0.08	1.5	0.2	35	1.78
Damietta			6.7	414	577	244	28	44	24	23	0.019	0.68	0.09	23	0.80
Average			6.3	353.78	532.73	201.3	44.9	42.62	22.45	27.05	0.06	1.17	0.17	37	1.14
Range			6 - 6.7	237-614	360-932	105-320	23-90	25-57.5	16.8-31.8	19.8-35.9	.019-.08	.68-1.76	.02- .39	23-58	0.8-1.78
	May 2011 collection														
Site	**Physical properties**					**Chemical propertiess**								**Fungal population**	
	A.T 0C	**W.T 0C**	**pH**	**TDS ppm**	**EC µS/cm**	**Alkalinity**	**Cl^- ppm**	**Ca^{2+} Ppm**	**Mg^{2+} ppm**	**SO_4^{2-} ppm**	**NO_2^- ppm**	**NH_3 ppm**	PO_4^{3-} **ppm**	**S.R**	**NRS**
Dakahlya	**Min. temperature (10 - 25) Max. temperature (22 - 40)**	**20-22**	7.68	168.5	336.5	121	27.75	27.0	16.4	22.18	0.01	0.09	0.15	56	1.21
Sharqiyah			7.5	186	383	139	30	35	20	23.97	0.01	0.07	0.07	30	1.19
Qalyubiya			7.2	187.3	372.7	121.3	33.3	32.8	21.2	21.5	0.05	0.06	0.08	49	0.81
Kafr El-Sheikh			7.6	244	410	141	34	45	23	35.7	0.06	0.15	0.06	24	1.23
El Behera			7.5	180	360	133	29	30	17	24.4	0.025	0.025	0.09	30	1.09
Gharbeyia			7.6	175	350	110	23	25.2	17	24.4	0.02	0.01	0.015	43	1.03
Menofya			7.5	188	355	140	34	30	18	30.3	0.077	1.48	0.02	36	1.0
Damietta			7.65	198.5	400	146.5	35	42	22.5	34.3	0.04	0.23	0.03	37	1.26
Average			7.46	184.3	367.67	128.5	31.2	32.5	19.53	25.16	0.03	0.21	0.07	38	1.10
Range			7.2 -7.7	168-244	336-400	110-1469	23-35	25-45	16.4-23	19.6-39.1	0.01-0.07	0.01-1.48	0.01-0.15	24-56	0.8-1.26

			December 2011 collection												
Dakahlya	Min. temperature (6 - 17) Max. temperature (18 -24)	10-12	7.7	323	505	172	49	31	15.2	39	0.06	0.26	0.012	52	0.95
Sharqiyah			7.8	377	589	193	55	36	18.8	45	0.15	0.4	0.08	24	0.73
Qalyubiya			7.4	315	448	173	47	33	16	37	0.008	0.2	0.02	42	1.05
Kafr El-Sheikh			7.3	364	510	207	31	35	20	35.7	0.04	0.25	0.08	24	0.85
El Behera			7.4	380	460	213	39	31	19	24.4	0.02	0.035	0.06	15	0.76
Gharbeyia			7.5	300	468	178	34	33	17.5	44	0.03	0.1	0.02	43	0.91
Menofya			7.5	310	746	169	45	34	17.5	46	0.04	0.3	0.013	41	0.9
Damietta			7.6	390	433	165	40	29	14.3	41	0.08	0.19	0.013	30	0.83
Average			7.53	345	520	183.8	42.5	32.8	17.3	39.01	0.05	0.2	0.04	33.8	87.3
Range			7.3-7.8	300-390	433- 746	165-213	31-55	29-36	14.3-20	24.4-46	.008-0.15	0.03-0.4	0.001-0.08	15-52	0.73-1.05

Table (1): The variation in physical and chemical parameters of the collected water samples from the eight governorates in different seasons.

A.T = Air temperature; W.T = Water temperature, TDS = Total dissolved salts: EC = Electric conductivity; S.R= Species richness; **NRS** = Number of records per sample.

Site	Physical properties				Chemical properties							Fungal records number				
	pH	TDS	EC	Alkalinity	Cl^-	Ca^{2+}	Mg^{2+}	SO_4^{2-}	NO_2^-	NH_3	PO_4^{3-}	NRS	As R	An R	B R	M R
Dakahlya	7.35	263.76	427.4	161.6	29.1	33.56	17.40	29.54	0.04	0.43	0.13	0.93	396	246	17	58
Sharqiyah	7.08	313.43	529.4	177.4	36.3	38.83	20.33	35.17	0.05	0.35	0.08	1.07	182	97	11	47
Qalyubiya	6.93	292.69	470.3	171.6	39.8	40.8	20.08	31.63	0.04	0.64	0.16	0.91	264	200	10	51
Kafr El-Sheikh	6.95	375.88	583.0	193.0	32.5	42.38	23.50	30.24	0.05	0.33	0.16	1.19	144	111	5	63
El Behera	6.98	308.88	469.0	192.7	32.1	37.75	19.25	28.08	0.03	0.45	0.10	1.02	135	69	3	30
Gharbeyia	7.18	242.63	397.5	138.0	25.7	30.05	18.00	33.60	0.03	0.48	0.02	0.96	295	185	9	50
Menofya	6.98	270.25	501.7	125.5	46.0	35.00	19.83	32.70	0.05	0.97	0.09	1.2	178	144	9	17
Damietta	7.19	328.13	477.0	166.9	30.5	38.75	20.70	32.83	0.05	0.29	0.05	1.04	204	102	0	12

Table (2): The correlation between average of physico-chemical parameters and the fungal recordsnumbers in the studied governorates.

Seasons	Physical properties							Chemical propertiess							Fungal records number				
	Min A.T ^0C	Max A.T ^0C	W.T ^0C	pH	TDS ppm	EC µS/cm	Alkalinity	Cl^- ppm	Ca^{2+} Ppm	Mg^{2+} ppm	SO_4^{2-} ppm	NO_2^- ppm	NH_3 ppm	PO_4^{3-} ppm	NRS	As R	An R	B R	M R
February 2010 (winter)	8-18	16-34	16-18	6.9	308.3	504.2	146.9	17.84	39.8	20.4	33.7	0.02	0.31	0.13	0.89	311	285	14	98
August 2010 (summer)	20-28	32-44	27-29	6.3	353.8	532.7	201.3	44.9	42.6	22.5	27.1	0.06	1.17	0.17	1.1	463	262	23	138

May 2011 (last spring)	**10-25**	**22-40**	**20-22**	**7.46**	**184.3**	**367.7**	**128.5**	**31.21**	**32.5**	**19.5**	**25.2**	**0.03**	**0.21**	**0.07**	**1.05**	**552**	**280**	**13**	**75**
December 2011 (autumn)	**6-17**	**18-24**	**10-12**	**7.5**	**345**	**520**	**183.8**	**42.5**	**32.8**	**17.3**	**39.0**	**0.05**	**0.2**	**0.04**	**1.0**	**472**	**327**	**14**	**17**

Table (3): Effect of average of physico-chemical and seasonal parameters on the number of fungal collections.

NRS = number of records per sample; As R = ascomycetes records, An R=anamorphic fungi record; BR = Basidiomycetesrecords; MR= Myxomycetes records.

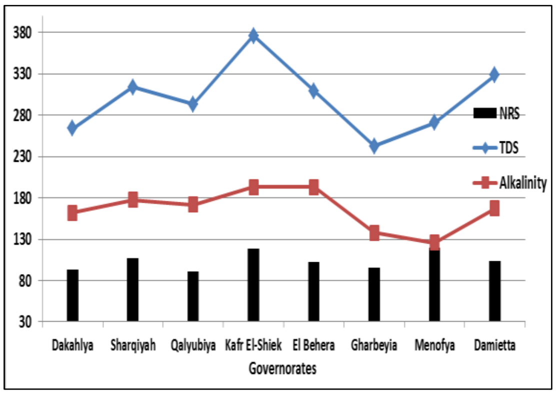

Fig. (1): The relation between number of fungal collections per sample andaverages of TDS, alkalinity in the eight studied governorates (NRS x 10^2).

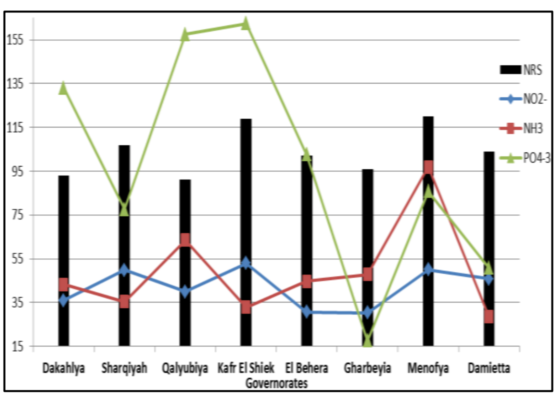

Fig. (2): The relation between numbers of records per sampleand averages of NO_2^-, NH_3 and PO_4^{3-} ions in the studied governorates(NRS, NO_2^-, NH_3, PO_4^{3-}x10 ^{2}).

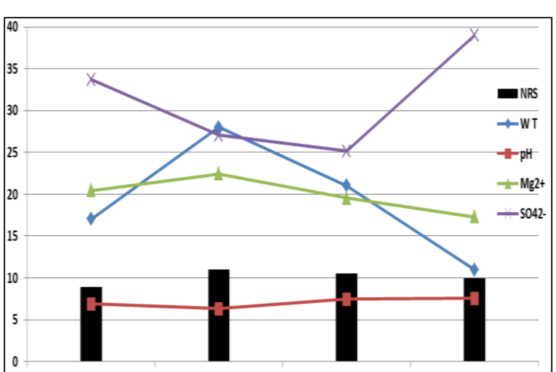

Fig. (3): The relation between numbers of records per sampleandaverages ofwater temperature, pH, Mg^{2+}, SO_4^{2-}in the studied seasons (NRS x 10).

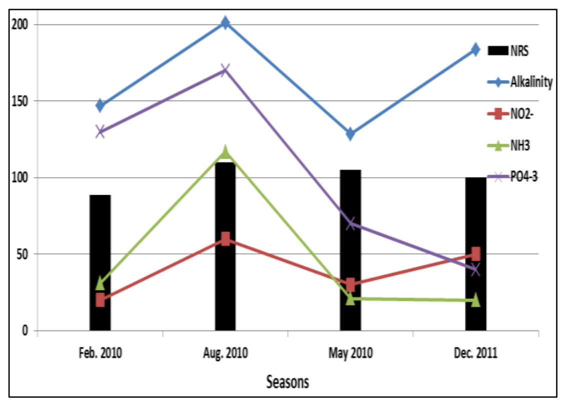

Fig. (4): The relation between numbers of records per sampleandaverages ofalkalinity, NO_2^-, NH_3 and PO_4^{3-} ions in the studied seasons (NRS, NO_2^-, NH_3, PO_4^{3-} x10 ^{2}).

The relationship between fungal distribution parameters and physicho-chemical analysis:

By using direct observation to the results, we cannot put constant base or direct correlation betweenphysicho-chemical analysis and biodiversity of fungi for example: the highest number of records per sample was recorded in Menofya governorate in August collectionand also the highest average of NO_2^- and NH_3^+were recorded in the same governorate.Otherwise, approximately the lowest average of TDS, alkalinity and Mg^{2+} were recorded in Menofya governorate (Tables 2 and 3).The lowest number of records per samplein December 2011 was reported in Sharqiyahgovernorates, where the concentration of Ca^{+2} and SO_4^{2-} was high.Many other examples of correlation patterns between physico-chemical parameters and fungal population were in Tables(1,2 and 3) and Figs. (1 to 4). In this study ascomycetes and anamorphic fungi records were high in governorates with low salinity(e.g. Dakahlya, Qalyubiya and Gharbeyia governorates). Some family like Halosphaeriaceae exhibited more preference to governorates with high total dissolved salts; Damietta, Sharqiyah and KafrEl-sheikh governorates.

We try to conclude clear relation between physico-chemical results and biodiversity of fungi using correspondence analysis (CCA). The environmental data were correlated with frequency of occurrence of fungal species data set, and the results for the CCA of governorates in relation to environmental variables were given in Table (4)and Fig. (5). Canonical correspondence analysis (CCA) triplot explained 41.6% of the variability in the fungal community and environmental data with 22.2% in axis 1 and 19.4% in axis 2 (Table 4). The orientation of the environmental axis reflects the direction of maximum change of that variable.The longer of the axis indicate to thestrengthofinfluenceof variable on community composition. Thus sites near or beyond the tip of an axis will be strongly positively correlated with and influenced by the environmental variable represented by that arrow. Axis 1 was negatively correlated with PO_4^{3-} and EC variables Likewise, a significant positive correlation of axis 1 was observed with pH average values. A significant positive correlation of axis 2 with NH_3 was observed, while it was significantly negatively correlated with alkalinity, TDS, Ca^{+2} and Mg^{2+} (Table 4 and Fig 5). There was no significant correlation of SO_4^{2-} andNO_2^- with both axes.

	CCA Axes	
Variables	1	2
Eigenvalue (%)	0.237 (22.2%)	0.207 (19.4%)
pH	0.46	0.12
TDS	0.01	-0.77
EC	-0.33	-0.45
Alkalinity	-0.08	-0.86
Cl-	-0.29	0.50
Ca^{+2}	-0.03	-0.60
Mg^{2+}	-0.13	-0.58
$SO4^{2-}$	0.11	0.14
NO_2^-	0.11	-0.07
NH_3	-0.30	0.87
PO_4^{3-}	-0.42	-0.20

Table 4: Summary of canonical correspondence analysis (CCA) using PAST software.

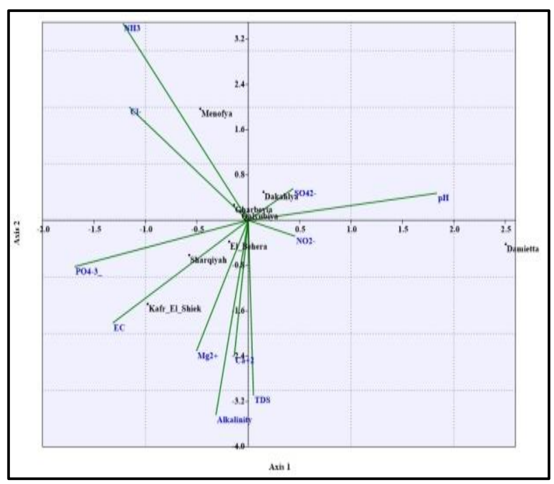

Fig. 5: Canonical correspondence analysis (CCA) plot explaining impact of environmental variables on species distribution

Discussion:

This part of the present investigation was planned to monitor the physico-chemical properties of water samples in river Nile streams in Delta region and study the effects of the changes in fungal distribution in the different governorates and seasons. The River

Nile and its streams in Egypt can be characterized to high, moderately and low polluted. The Nile water is of high quality as the river reaches Cairo. Deterioration in water quality occurs when the Nile splits into the Damietta and Rosetta branches in a northward direction due to industrial effluents and agricultural drainage with decreasing flows (World Bank 2005).

The distribution pattern of fungi within streams can be profoundly altered by human activities, including the input of nutrients, sewage, pesticides and industrial wastes (Bärlocher 1992b). Factors affecting colonization of fungi involve types of substratum, temperature, relative humidity, the season of sampling, water chemistry and geographical location (Kohlmeyer and Kholmeyer 1979; Hudson 1986). Air and water temperature were ones of the main factors effecting on the fungal distribution between different seasons collections. The highest species richness and ascomycete records were observed in summer and May collections while anamorphic fungi records were high in February and December collections. Shearer (1972) and Suberkropp (1984) found that seasonal changes in temperature affected the occurrence of aquatic ascomycetes and hyphomycetes.

Chamier (1992) reviewed a number of important factors that effect on the fungal communities inside the stream such as water temperature, conductivity, pH, nitrate and phosphorus concentration. Furthermore, Hu *et al*. (2010) suggested that changes in water aeration, pH and turbidity may be causal factors on fungal communities. In this investigation pH values was slightly fluctuated and not exceeded 7.8 and contrary correlated with most fungal distribution parameters in Nile Delta region. The pH value is particularly play a crucial role in determining the fungal diversity and their composition. Dubey *et al*. (1994) stated that the increase in water acidity lead to reduce the diversity of aquatic hyphomycetes in West Virginia. Also, Bärlocher and Rosset (1981) reported that the fungal diversity in soft water streams was higher than those in hard water streams where the pH was higher. The fluctuation in pH arises from different industrial effluents and agricultural drainage in waters.

Electric conductivity of Nile water samples exhibited great differences between the different governorates and different season's samples. Electric conductivity and alkalinity have a contrary effect on the most fungal distribution parameters in studied governorates and seasons.The increase in the EC was resulting from agricultural drainage which has high conductivity (APHA 1998; Gali *et al*. 2012).Salinity played active role in determining fungal diversity and community composition in this study. Less is known about the variation of fungal diversity and composition along latitude, altitude and salinity gradients (Mohamed and Martiny 2010). In general there was decrease in fungal diversity with increasing salinity in this study.

Ammonia and phosphate have enhancing effect in most distribution parameter in this investigation. The level of nitrates and phosphate in water has been regarded as important limiting factors in determining rates of detritus degradation (Elwood *et al*. 1981; Suberkropp and Chauvet 1995). Sridhar and Bärlocher (1997) found that the sporulation of aquatic hyphomycetes was stimulated by increasing nitrates. The presence or increase in NO_2^- and NH_3^+ in some streams may be resulting from fertilizer that may be present in the soil and it easily oxidized to nitrite (Karavoltsos *et al*. 2008).There was no significant correlation of SO_4^{2-} andNO_2^- with fungi reported during this study.Suberkropp *et al*. (1988) found that the aquatic hyphomycetes community was unaffected by the effluents discharged from a sewage treatment plant.

Shearer (1972) studied the distribution of aquatic ascomycetes at 5 stations along river in Chesapeake Bay. She found that 6 species collected at station 1 and 3 were not collected at station 2 and suggested that was probably because of the effluents discharged from a sewage treatment plant near station 2. Tsui *et al.* (2001) investigated the longitudinal and temporal distribution of freshwater ascomycetes and hyphomycetes on submerged wood in the Lam Tsuen River in Hong Kong, and found that the fungal species composition changed correlated with concentrations of NO3 -N, NH_3 -N, and PO_4 -P resulting from human disturbance. Luo *et al*. (2004) compared the fungal communities and diversity between Lake Fuxian (an unpolluted lake) and Lake Dianchi (a heavily polluted lake), and concluded that pollution causes change in the fungal communities, but had little effect on fungal diversity. The number of fungal species in submerged wood may not be good bio- indicators of organic pollution (Tsui *et al*. 2001). Au *et al*. (1992) and Raviraja *et al*. (1998) compared the species diversity in unpolluted and polluted streams located geographically close together. They observed that freshwater fungi diversity, species richness and conidial production were reduced with organic pollution in the polluted streams.

Ca^{+2} and Mg^{2+} concentrationwere negatively correlated with fungal communities. However, physico-chemical parameters such as SO_4^{2-} andNO_2^{-}they were not having significant correlation on fungal communities. Many metals e.g., copper (Cu), magnesium (Mg), potassium (K), sodium (Na), iron (Fe) are essential to fungal growth, development and differentiation (Hughes and Poole 1991). However, metals can be toxic above a critical concentration that depends on the organism, the physico-chemical properties of the metal, and the environmental factors (Gadd 1993; Blaudez *et al*. 2000; Gimmler *et al*. 2001). Although fungal diversity has been recognized to decrease due to heavy metal exposure (Bermingham *et al*. 1996), several species of aquatic hyphomycetes have been found in metal-polluted streams (Krauss *et al*. 2001; Pascoal *et al.* 2005).

Fluctuation observedhereinphysicho-chemicalparametersare probably due to combination of several factors including industrial, agricultural and domestic waste discharge. Results from CCA analysis of the fungal assemblages found at the eight governorates revealed that changes in species composition were correlated with elevated concentrations of NH_3, and pH resulting from domestic and agricultural activities in River Nile streams.

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الملخص العربي

العلاقه بين الخواص الكيميائيه والفيزيائيه لتفرعات نهر النيل والتنوع الفطري في منطقه الدلتا (مصر)

الخلاصة

تلوث مياه نهر النيل في في مصر في ازدياد دائم مع استمرار تدفق النفايات بشكل مستمر. عينات من المياه جمعت من ترع وتفرعات نهر النيل الاساسيه من ثمان محافظات في الدلتا علي مدار اربع مواسم مختلفه في الفتره من فبراير 2010 الي ديسمبر 2011. العديد من العلاقات ما بين خواص المياه الكيميائيه والفيزيائيه والتنوع الفطري في منطقة الدلتا تم دراستها.درجة حرارة الهواء والماء كانت من اكثر العوامل الاساسيه الموثره علي توزيع الفطريات. تركيز الكالسيوم والمغنسيوم كان لها تاثير عكسي علي تواجد الفطريات بينما تواجد الكبريتات والنيتريت لم يكن لها تأثير واضح.الامونيا والفوسفات كان لهم تأثير محفز لتوزيع الفطريات في منطقة الدلتا. ملوحة المياه كان لها تأثير واضح علي تحديد نوعية وتنوع الفطريات في منطقة الدراسه.