MS EXCEL BUILT-IN PROGRAM FOR FLOW AND CHANNEL PROFILE DETERMINATION

Florian PĂUN, Mirel Ciprian PĂUN

National Institute of Marine Geology and Geo-ecology (GeoEcoMar),
304, Mamaia Blvd., 900581 Constantza, Romania
e-mail: miricip@zappmobile.ro

Abstract. The results of the program are the following: a quick display of the flow through a transversal section; display of the section's area and of its profile, all these in the same worksheet as the input data (bathymetric data, speeds and depths measured on a minimum number of at least 3 "verticals" on each profile). Also, the possibility to use then, for processing and presenting output data, all the graphical and tabular MS Office facilities for selecting, copying, pasting, resizing, moving, font formatting, aligning, coloring, text-tables and graphics transferring between applications, sorting, filtering, reports and pivot-tables realization... as the main purpose of direct MS Excel "built-in" programs, is to allow work as if everything would have been programmed by Microsoft itself, from the raw data input, intermediate and final processing to the final results presentation, all in a single Workbook, by mere mouse clicks on a toolbar' buttons, independent but absolutely similar to the Excel original ones.

Key words: flow, transversal section area, channel profile, speeds and medium speeds, depths, GPS assisted positioning

This complex program performs:

1. transversal section area's integral computerized calculus for any running water,
2. channel profile's graphical represen- tations (depth dependent on the left/right border distance, expressed in meters or geographic coordinates), based on bathymetry results and on a small number of measurements on selected profile's verticals,
3. the section's flow calculus, by many methods, based on different hydrological models (and the program's authors can easily implement, on request, any other desired model, for any researcher that will address to them).

The program has routines for computerized preparation of all input data, results, in different formats and combinations, from other programs and devices, such as:

- routine for synchronizing bathymetry (depths) data and GPS position, their processing in the format desired for the next stage, by retaining the useful columns only (from the multitude of columns given by GPS),
- routine for filtering bathymetry data at intervals desired by different end-users, (the bathymetric data sorting at 10 or 20 or 30 seconds only, for example, from the very big data number offered by the bathymetric device, at every second, generally),
- routines to parcel out and process by columns separated on degrees, minutes and thousandths, the latitude and longitude geographical coordinates; obtaining any desired formats for those,
- different subroutines included in the main routine for areas and flow calculus, for coordinates and distances to borders calculus for the projection points of all bathymetry as well as of all "verticals" for depths-speeds on the straight line that join the two marks previously chosen on the two river borders,
- routine for on screen bathymetric complete profile instant display, in coordinates and depths, in order to allow fast selection, immediately after finishing preceding bathymetry, of the best positions for the "verticals" of the speeds-depths measurements by the flow meter or other adequate device; these selected positions will be given to the ship's commander for a most precise positioning of the ship on the desired coordinates, for the next stage,
- routine to determine on "vertical" mean speed, by a corresponding specific calculus formula,

- routines to determine the 6-degree polynomial functions that approximate the channel profile's real curves,
- routines to implement the desired hydrological models,
- routines to compute the partial and total areas, and partial and total flows, based both on bathymetry (with as few or as many filtered data as one wishes), as well as on the "verticals" only (minimum 3, but the precision obviously grows with the number of "verticals" on each profile).

Once the input data (already pre-prepared by using the first routines anteriorly presented: depths, East and North geographical positions, and in the bottom part, of the "verticals", the mean speeds' column is also completed) is adequately introduced, a simple mouse click on the (built-in Excel) DEB button is needed, which will start practically instantly the automated achievement of all tabular and graphical desired results, presented in Figs. 1 and 2 and in Table 1.

The program is exemplified with the Sf. Gheorghe km108.4 profile from the 2004 campaign.

First, the final desired results, coloured in red automatically by the program for their immediate emphasizing are presented;

These are the total flows of: 2423.62 (m^3/s) – computed based on the given profile by the 5 "verticals" only, and then 2718.35 (m^3/s) and 2706.87 (m^3/s), respectively. They are computed based on the much accurate profile, from much more depths, supplied by the preceding bathymetry, but restricted to the same number of 5 mean speeds only, for the 5 "verticals". The mean speeds are distributed by the program to the multitude of bathymetry points, according to two models, md1- based on the principle of proximity to the verticals, and md2-, the model of the linear variation of the speed between two successive "verticals"; Any other speeds variation model, imposed by hydrological studies is easy to implement, but the variations do not exceed very few percentages. There is a greater difference only from the first value, in which the channel profile is approximated by just 5 depth measurements, on the 5 "verticals".

Immediately to the left of the total flows' red values', there are the red figures of the total section's areas, namely 3035.41 (m^2), computed based on bathymetry's dozens of points, and 2779.56 (m^2). The latter is an obviously smaller and less accurate value, as it is calculated based on a smaller number of depths: those corresponding to the "verticals" chosen for the speeds' measurement in 6 layers (speed horizons) and on mean speed computation.

In figure 1, the 4 graphics automatically obtained are included, simultaneously with table 1, with titles according to the presented data, namely

1°-Lat.N-Long.E, with the measurement points' geographic positions (in thousandths of degree) as well as with their projections on the line joining the two borders marks;

2°-Depths(m)-Distances(m):

3°-Depths(m)-Eastern Longitude

4°-Depths(m)- Inverse Distances (m)

In figure 2, the Depths(m)-Distances(m) presentation is resumed, this time at exactly the same scale on ordinate as well as on the abscissa, in order to have the real, undistorted profile image, without the horizontal compression from the last 3 previous graphics. We do that because, though in metres too, the depth and the distances from the borders differ substantially by an order of magnitude, from 20…30 metres for maximum depths to 300…900 metres for channel's profile width.

The table is structured on an upper side, for the bathymetry points, and a lower one, for the "verticals" points (minimum 3 and maximum as many as the fuel cost allows), separated by the two points of the two border marks coordinates. Those points also border each of the two groups for bathymetry and "verticals", in order to close the profiles at the river borders, where the depth and river speed are considered null.

As the columns' significance is identical, the units of measurement are displayed only once, in the intermediate part of the two zones (*i.e.,* bathymetry and "verticals"), in magenta, but they aren't crucially necessary, all data and computations being made in the SI units (m, m^2, m^3, m^3/s).

Detailing the program's presentation, here are, from left to right, the table's columns significance:

45, in the first cell, [A1], tells to the program to use the degree-minute-thausandths of minute transforming relations that are valid for the 45° latitude parallel, of Sf.Gh.km108, which exemplifies the program,

E, on column 1, A, signifies the East coordinate, the longitude, used as abscissa in the first two graphics, on the left side.

N, on column 2, B, the North coordinate, the latitude, used as ordinate in the first graphic, left-up corner, from the 4, to which the **b** letter is attached for the upper zone, of the bathymetry, the **D** letter for the line joining the two river borders marks (on this line both the bathymetry's points as well as the 3…5 or even more "verticals" measurement points are projected, by drawing perpendiculars) and the **v** letter for the lower zone, of the "verticals" measurements by the "handmill" (flow-metre) or other device, in the 6 layers or continuously, thus obtaining the titles **Nb**, **ND** and **Nv.**

np, the ordinates at the origin, in the East-North plane, of the perpendicular lines drawn, from the bathymetry's and verticals' points, on the line joining the two border points, orange coloured line on the first, trajectories' graphic.

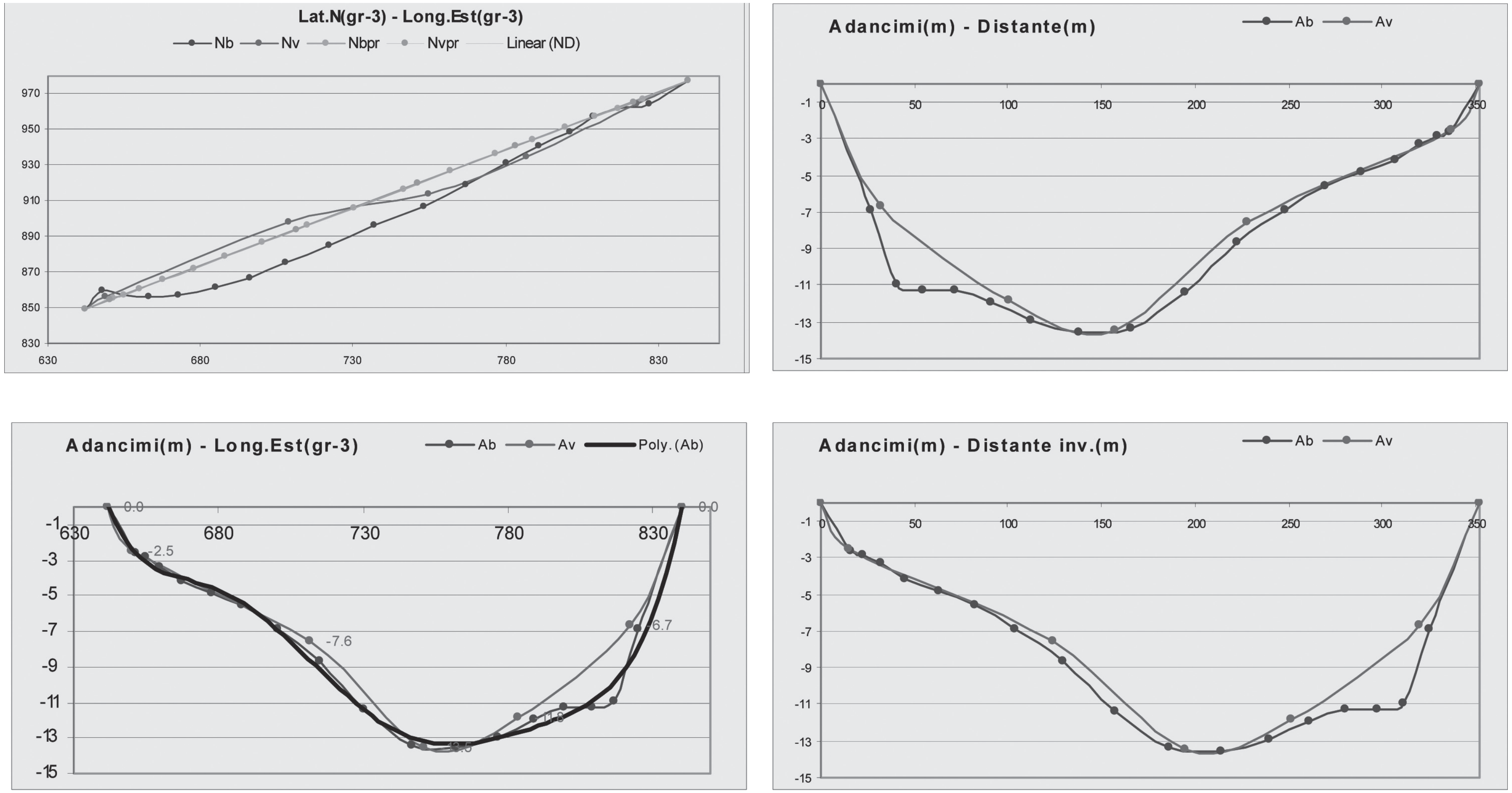

Fig.1 The 4 graphics automatically drawn by the program togther with the calculs of the section area and of the water flow into the section

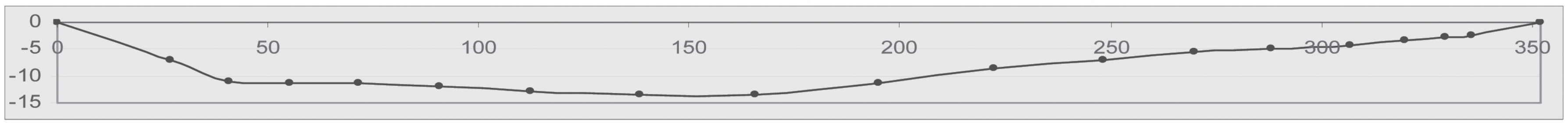

Fig.2 The actual shape of the Danube basin in the studied section (the same horizontal scale for the distances from the border and depths)

Ebpr and **Nbpr**, columns 4 and 5, the E and N coordinates of the light blue projection points on the orange line, of the dark blue bathymetry's points, from the columns 1 and 2 of the upper part of the table.

Evpr and **Nvpr**, columns 4 and 5 of the lower side, the E and N coordinates for the orange points of projecting on the same line the Verticals' red points from columns 1 and 2 of the lower part of the table.

D and **Dinv**, columns 6 and 7, the distances of each bathymetric point or vertical measurement, to one border and to the other border, respectively.

Ab and **Av**, respectively, on column 8, of bathymetric depths - up and of Verticals, down, respectively, is the column of input data.

Vm, column 9, for mean speeds, is automatically completed by the program, in the upper part, the Bathymetry part, with the speed mean values read from the lower part, the Verticals' part (input data), according to the criterion of the proximity of each bathymetric point (its projection on the straight line, to be more exact) to the closest speed measure-ments vertical (that is, a mean speeds repartition to all the bathymetry points, according to the criterion of proximity to the flow-metre Verticals measurements, as well as **Vlin**, in the last column, 13, contains the repartition into the bathymetry points for the same mean speeds, but according to another model, for comparison, the model of linear speed variation between verticals; any other hydrologic model can be attached).

Column 10, **Arii,** (areas), calculates the elementary areas, between two successive bathymetric points in the upper zone, between two successive Verticals in the lower zone, respectively.

Column 11, **Debite,** (Flow), calculates the elementary flow for each elementary surface, multiplying the elementary areas by their respective elementary surfaces (DebiteB, up, in the bathymetry zone, and DebiteV, down, in the Verticals zone). Likewise, **DebL**, in column 12, calculates the elementary flows based on the model 2, of mean speeds linear variation, from column 13, **Vml**.

Under the latter semi-columns, in red, there are the sums of the total areas and flows, as final results (with which we, in fact, begun our presentation).

The first graphic, I, upper-left, "Trajectories", was already entirely described, when the table was presented, and the 3 subsequent graphics from Fig.1. display the channel's profile as follows:

The second graphic, II, in the bottom-left corner, represents additionally, in blue, the bathymetry projections curve; in red, the 5 Verticals projections depths (with the values enclosed), and in black, the curve of the 6 degree polygon. It best approximates, as a function, the blue bathymetric curve, while the equation of the 6 degree function is written, just in the middle of the 3 functions, under the table: the first function, of degree 1, is, obviously, the equation of the line joining the two borders, on which the bathymetry and the Verticals profile are projected, while the last, third function is the polynomial function of also of degree 6, (the maximum degree with which Excel and its incorporated language, VBA, work), which best approximate the red, Verticals profile curve. The writing of these functions was programmed for their further use in the most precise areas calculus by integrating these functions between the limits of the borders, after a separate mathematical-physical discussion. The ordinate of this second graphic, *i.e.,* II, (depths graphic) is obviously **depth**, while its abscissa is the East latitude, in thousandths of a minute (exactly in the same way as for the first graphic, I).

The last two graphics, III and IV, in right side, also represent the depths, in metres, but not as functions of the East geographic coordinate, but as function of the distances to the two borders, in metres (D, to a border, and Dinv to the other border).

All the last 3 graphics clearly show smaller areas closed by the red (Verticals depths) curves, than the areas closed by the blue (bathymetry) curves, which is based on many more measurement points, that is on a much better approximation of the channel bed profile, thus graphically justifying the bigger values, in red, based on bathymetry, than those based only on a few Verticals in approximating the bed channel profile and its section area.

A still better approximation, still closer to the real values, can be obtained by using in the upper, bathymetry part, all registered bathymetric points, 5 time more numerous, a value at every 2 seconds as compared to the method presented until now, in which the bathymetric values were filtered from 10 to 10 seconds, as required. Only the final results of this new calculus is directly given, based on the entire bathymetric registration, 3026.35 (m^2) for the total area and 2749.48 (m^3/s) for the total flow, (without the entire table type 1 and the entire figure type 1 for the entire bathymetry), all that only to emphasize the fact that these values, naturally the most accurate, are however with only 1.27% more precise for flows and with a still smaller percentage for the total area, a fact that completely justifies the bathymetry points filtering ("decimation") use, at every 10 seconds instead of every 2 seconds, as the total registration is made. The line's equation is normally the same, while the 6 degree curves' equations differ by the small, insignificant powers only, (1 and 2, at the most 3 powers). It should be emphasized that our method for areas calculus is most accurate, approaching, in fact, the integral's definition (just the Darboux sums, in fact, before passing to the "limit" process).

On the first table's line, at the right of latitude's degrees' value (45, in our exemplification), the program automatically completes a series of intermediate values, very useful for the next calculations, as well as for controlling the accuracy of the results' (by the programmer and user), such as the straight line's slope, its origin ordinate, the slope of the perpendicular projections on this line which join the channel's borders, the values in meters, on latitude and longitude, at the exact value of the sample's latitude, etc.

It should be mentioned that the program is very, very precise when using a maximum number of decimals. Yet the final results' precision essentially depends on the precision of the input data, that is on the precision of the devices, on the methods used and on the specialist who works with it.

45	0.6465	433.97	1.54695	1.314117	1.8522		630.0	850	830	980	-15	351.9973
E	Nb	np	Ebpr	Nbpr	Dbinv	Db	Ab	Vbm	AriiB	DebiteB	DebL	VmL
840	977	2276	840.0	977.0	352.0	0.0	0.0	0.000				
827	964	2243	824.9	967.3	325.2	26.8	-6.9	0.694	92.80	64.40	54.24	0.585
817	962	2226	816.9	962.1	311.0	41.0	-10.9	0.694	126.44	87.75	94.56	0.748
809	957	2208	809.0	957.0	296.9	55.1	-11.3	0.694	156.68	108.73	130.15	0.831
801	949	2188	799.7	951.0	280.4	71.6	-11.3	1.098	186.62	204.91	173.17	0.928
791	941	2165	789.0	944.1	261.4	90.6	-11.9	1.098	220.66	242.29	229.46	1.040
780	931	2138	776.7	936.1	239.5	112.5	-13.0	1.098	272.41	299.10	293.72	1.078
767	919	2106	762.1	926.6	213.5	138.5	-13.6	1.004	345.24	346.62	357.47	1.035
753	907	2072	746.7	916.7	186.2	165.8	-13.4	1.004	367.87	369.35	364.11	0.990
737	896	2036	730.4	906.2	157.2	194.8	-11.4	0.881	358.60	315.92	336.83	0.939
722	885	2002	714.8	896.1	129.5	222.5	-8.7	0.881	277.51	244.49	247.27	0.891
708	875	1970	700.4	886.8	103.8	248.2	-6.9	0.881	199.63	175.87	161.08	0.807
696	867	1944	688.3	878.9	82.3	269.7	-5.6	0.881	134.24	118.27	97.55	0.727
685	861	1921	677.8	872.2	63.6	288.4	-4.9	0.474	97.29	46.11	63.94	0.657
673	857	1898	667.5	865.5	45.4	306.6	-4.2	0.474	82.39	39.05	48.54	0.589
663	856	1882	660.0	860.7	32.0	320.0	-3.3	0.474	49.99	23.70	26.96	0.539
655	857	1870	654.8	857.3	22.8	329.2	-2.9	0.474	28.49	13.50	14.39	0.505
648	860	1862	651.2	855.0	16.4	335.6	-2.6	0.474	17.26	8.18	8.31	0.481
642	849	1842	642.0	849.0	0.0	352.0	0.0	0.474	21.29	10.09	5.12	0.241
E	ND								3035.41	2718.35	2706.87	
840	977		gr-3	gr-3	m	m	m	m/s	mp	m3/s	m3/s	m/s
642	849											
E	Nv	np	Evpr	Nvpr	Dvinv	Dv	Av	Vvm	AriiV	DebiteV		
840	977	2276	840.0	977.0	352.0	0.0	0.0	0.000				
823	964	2237	822.1	965.4	320.2	31.8	-6.7	0.694	106.52	73.92		
787	935	2152	783.5	940.5	251.5	100.5	-11.8	1.098	634.96	697.18		
755	914	2082	751.3	919.7	194.4	157.6	-13.5	1.004	722.88	725.77		
709	898	1995	711.6	894.0	123.7	228.3	-7.6	0.881	745.31	656.62		
649	856	1860	650.1	854.3	14.5	337.5	-2.5	0.474	551.83	261.57		
642	849	1842	642.0	849.0	0.0	352.0	0.0	0.474	18.06	8.56		
									2779.56	2423.62		

y = 0.6465x + 433.97

y = 3E-11x6 - 1E-07x5 + 0.0002x4 - 0.2283x3 + 126.05x2 - 37057x + 5E+06

y = 4E-11x6 - 2E-07x5 + 0.0003x4 - 0.293x3 + 162.58x2 - 48023x + 6E+06

Tab.1 The input, intermediate and output data. The final form triggerred by a click on the DEB button

It should be again underlined that a national and even an international collaboration for establishing the best profiles on the Danube, the good marking of all these profiles with good marks on both borders (stable and visible, at least electronically, in the worst weather and environmental conditions, flood and tempest including), stable for the following dozens of years, with precisely known coordinates, would distinctly improve and facilitate the Danube's and its tributaries flow and profile monitoring. So, a database can be created which would permit the positioning always not only on the same profiles, but also on the same verticals in the profiles. The year on year comparisons would be thus done based on just a single annual Vertical only.

The measurements, both bathymetrical and by flow meter, can be more accurately made using very small boats, more precisely positioned and more easily preserved on the chosen positions.

More precise results can also be obtained by doubling the number of the devices, on both boat borders, and also doubling the Verticals measurements for the same number of positions of the boat, that is, for the same fuel consumption.

Another most important special desideratum is to place the GPS and the bathymetry devices as near as possible to the flow-metre emplacement, for the place of the measurements to coincide. Also, a complex transducer, for depth and speeds in the same unit, would eliminate any other supplementary errors, especially when measuring the depth based on hydrostatical pressure (that is, apart form the current speed and angle between the vertical and the transducer's cable). The detailed and chronological algorithm to use this program is the following:

- the Debite toolbar display (Excel standard proceeding: VIEW, Toolbars, Debite), that contains two incorporated buttons: DEC and DEB.
- bathymetry data processing (in a sheet named, for example, BatOrigin) at a simple click on the DEC ("decimation") button.
- the processing of these results according to the prototype from TransformPunctVirg.xls (which keeps the needed transform formulae in its second line), by mere rolling the mouse, from up to down, for the second selected line, over all data.
- from the new results, only the further useful ones are copied [Depths, E-thousandths, N- thousandths] and Past on a new sheet, renamed, for example [E, N, Ad]
- the completion of the first cell with the value of the parallel on which the profile is situated, in order that the program reads it from here and automatically uses it in transforming the geographical coordinates in metres, for the correct distances, areas and flow calculus. In our example, [A1].value=45
- the minus sign is assigned to the entire depths column (for a correct graphic representation of the column under the axis) and the depths are moved to column 8.

Conversion to NUMBER-format of the columns [1:2], that is [E,N], in order not to be treated as text. Their selection, with or without title, and the realization of a preliminary diagram, according to the Excel std. method (INSERT→CHART, type=xyScatter), the elimination of the edges ("S" trajectory' curvatures) in order to keep only the trajectory's linear part; the appropriate elimination of the Parasite data from the beginning and end of the bathymetry trajectory.

- the adding of the borders coordinates, MS and MD, left and right border.
- selection of E (East) and Ab (bathymetry depths) and quick display of the bathymetry diagram (INSERT→CHART, type=xyScatter) for selecting immediately the Verticals positions, that will be given to the ship's commander to best position its boat, using these data and the GPS.
- completion, under bathymetry, two lines by two columns, for the line joining the borders marks, MS, MD; further completion, with data obtained by the Verticals' measurements, (minimum 3, but better, 5 or even more, depending on the complexity of the profile, channels or sub-channels), also bordered, up and down, with the two borders values, for curves' closing.
- completion with mean speeds, by averaging flow-metre data.
- click on the special Excel built-in DEB button, to compute flow, and the Table 1 and the 4 graphics of Fig.1 are instantly automatically completed, together with a new graphic, for the real profile's shape. Here, the same metric scales are used horizontally and vertically, that is, for horizontal distances and vertical depths.

REFERENCES

F.L. Păun, M.C. Păun, 2004 – MSExcel built-in Program for Analytic and Synthetic Ecological Indices Describing Ecosystems,Geo-Eco-Marina 9/10 2003-2004

*** Microsoft Excel User's Guide

*** Microsoft Excel Visual Basic User's Guide

*** Microsoft Excel Visual Basic Reference

*** Microsoft VBA (Visual Basic for Applications)

*** Microsoft OLE Automation with Applications (MSWord, MS-Excel, MS-Project).