BASIN BOUNDARY PROBLEM IN THE PORSUK CREEK BASIN, TURKEY

Tevfik ERKAL[1], İlyas Sadık TEKKANAT[2]

Abstract

In this study, the basin boundary problem in Porsuk Brook Basin, which has high vulnerability to pollution, flood and mild drought, and the geographical location and area (km^2) of the basin are defined. Main purpose of the work is correctly by creating the basin area completing the missing basin location information and correcting false location maps. In the manual determination according to the WGS84 system, the area of the Porsuk Creek Basin is 10829,92 km^2 and 10830,25 km^2 in the automatic determination. The basin is composed of 4 morphological sections in the form of Lower, Middle, Upper and Uppermost Section. The basin boundary problem is that a large area is not included in the Uppermost Section, and this area corresponds to ~414 km^2 [~58000 football fields or 1,5 times the Gökçeada (Imbros)]. Although it is not mentioned in the geographical position information Bilecik province and Afyonkarahisar/İhsaniye is located within the basin area. The research findings refer to the faults observed at the basin boundary of the Porsuk Creek. The results of the study were found to be important for the integrated river basin management.

Keywords: Basin Boundary, Basin Area, Morphological Section, Integrated River Basin Management, Porsuk Creek Basin.

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PORSUK ÇAYI HAVZASINDA HAVZA SINIR SORUNU

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Öz

Bu çalışmada, kirlilik, taşkın ve hafif kuraklıklara karşı kırılganlığı yüksek olan Porsuk Çayı Havzası'nda havza sınır sorunu ve buna ek olarak havzanın coğrafi konumu ve alanı (km^2) tanımlanmıştır. Çalışmanın ana amacı havza alanını doğru bir şekilde çıkararak bazı çalışmalarda kullanılan eksik havza konum bilgisini tamamlamak ve hatalı konum haritalarını düzeltmektir. WGS84 sistemine göre manuel belirlemede Porsuk Çayı Havzası'nın alanı 10829,92 km^2, otomatik belirlemede ise 10830,25 km^2 olarak tespit edilmiştir. Havza Alt, Orta, Üst ve En üst Bölüm şeklinde 4 morfolojik bölümden oluşmaktadır. Porsuk Çayı Havzası sınır problemi havzanın en üst bölümünde büyükçe bir alanın havza alanına dâhil edilmemesidir ve bu alan ~414 km^2'ye (~58000 futbol sahasına ya da Gökçeada'nın 1,5 katına) karşılık gelmektedir. Coğrafi konum bilgisinde belirtilmese de Bilecik ili ve Afyonkarahisar/İhsaniye ilçe merkezi havza alanı içerisinde yer almaktadır. Bulgular Porsuk Çayı'nın havza sınırında gözlenen hatalara işaret etmektedir. Çalışma sonuçları entegre havza yönetimi açısından önemli bulunmuştur.

***Anahtar Kelimeler*:** Havza Sınırı, Havza Alanı, Morfolojik Bölüm, Entegre Havza Yönetimi, Porsuk Çayı Havzası

Introduction

The drainage basin in hydrology has always been a focus point in the studies of water movement in the hydrological cycle. It can be established a relationship between the various hazards and disasters triggered by the water, such as flood, sheet-flood and landslide and physiographic characteristics of the drainage basin (size of the drainage area, shape, slope, drainage density, tributary lengths, slope, etc.) (Rastogi et al., 1976). River basins are also considered as a geomorphic system or geomorphic unit (Leopold et al., 1964; Chorley, 1969; Christopher et al., 2010). In general, studies on the fluvial system and its elements; in special, in fluvial geomorphological studies, these regions are taken into account as a spatial scale. River basins which are an important element of ecology are also generally used in ecological studies (Frissell et al., 1986; Gallagher, 1999).

It taking into account drainage basins and morphological sections in understanding of the scope and effects of possible environmental problems (such as *drought, water quality degradation, environmental pollution, land degradation, erosion, flood and deforestation*) in the basin and improving of the practical consequences, analyzing better of the fluvial system, integrated river basin management approach and Environmental Impact Assessment (EIA) approach are of great importance in studies related to environmental problems. For this reason, it is necessary for both river basin and morphological sections to be detected accurately (Hajam et al., 2013, Alqaysi and Almuslehi, 2016, Daffi and Ohuchaogu, 2017; Rai, et al., 2017).

The spatial scale of this study is the Porsuk Creek Basin (PCB). It is seen that some areas at the Uppermost Section are not included to drainage basin in various studies conducted on the scale of PCB and morphological section (Arslan, 2008; Bakış et al., 2008; Arslan, 2009; Büyükerşen and Efelerli, 2008; Bakış et al., 2011; Çetin et al., 2011, Şimşek, 2014). This changes morphometric properties of the basin. For this reason, it is need to re-identify the drainage basin, emphasize the problematic area, evaluate the cause/s of the problem, rearrange the geographical location and physical geographical features of the basin. In this context, this study focuses on the problem of basin boundary and the geographical location of the basin.

Materials and Methods

A layer of contour line of 20 m intervals and twelve topographic maps (i23-i27, j23-j27, k23, k24) with a scale of 1:100.000 obtained from the General Command of Mapping (GCM) as base are used to manually determine.

ArcGIS Hydrology toolset of the Spatial Analyst extension is used for automatic determination of basin boundary.

The stages of the hydrological analysis are as follows:

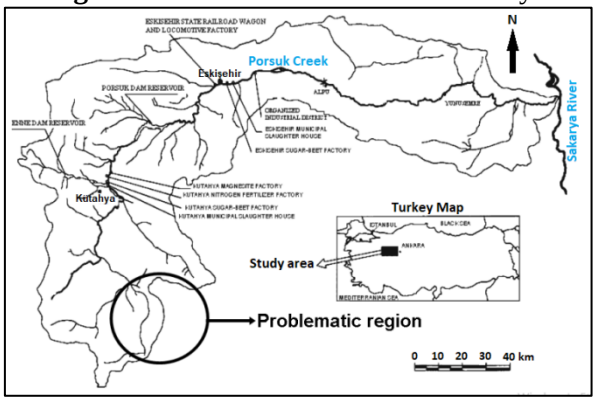
- The sinks in the Digital Elevation Model (DEM) obtained from the Shuttle Radar Topography Mission (SRTM) data of a wide area surrounding the Porsuk Creek are filled,
- Flow direction and flow accumulation are created on the DEM filled in the sinks,
- PCB is delineated by using the Basin tool.
- A stream order based on the method of stream ordering proposed by Strahler in 1952 was created,
- Stream networks are delineated from the DEM using the output from the Flow Accumulation tool, and finally were converted the river basin area raster and stream network raster to vector data format.

MapInfo (version 10.5) and ArcGIS (version 10) Geographic Information Systems (GIS) programs are used in coding of the relevant geographical items (contour lines and settlement centers), generating thematic maps and extracting spatial values.

Results

A basin boundary problem was identified in the PCB. The problem is that some of the areas from Afyonkarahisar and Bilecik provinces are not included in the PCB and the borders are rather smoothed (Figure 1).

Figure 1: Location of the PCB in Turkey*



Reference: Kutlu et al., 2004; Muhammetoğlu et al., 2005; Arslan, 2008, 2009; Altın, Filiz and İşcen, 2009; Çetin et al., 2011; Köse et al., 2012.
*The circle areas show the basin boundary problem.

The study area is the PCB which is a tributary of the Sakarya River. The basin covers an area of 10830 km^2. It is 201 km in the east-west direction and 135 km in the north-south direction. It is located between 29°38′–31°59′ E and 38°44′–39°99′ N in northwest Anatolia, which covers three regions: the Aegean, Marmara and Central Anatolian Region. Moreover, PCB comprises Upper Sakarya Trough, Porsuk Through and Sündiken Mountain Chain Area. The study area of the PCB in the province and district scale cover eight district centers: the Alpu, Beylikova, Mihalıççık, İnönü, Aslanapa, Altıntaş, İhsaniye and Dumlupınar and two province centers: the Eskişehir and Kütahya and six provinces: the Ankara, Eskişehir, Kütahya, Bilecik, Uşak and Afyonkarahisar (Figure 2a and 2b).

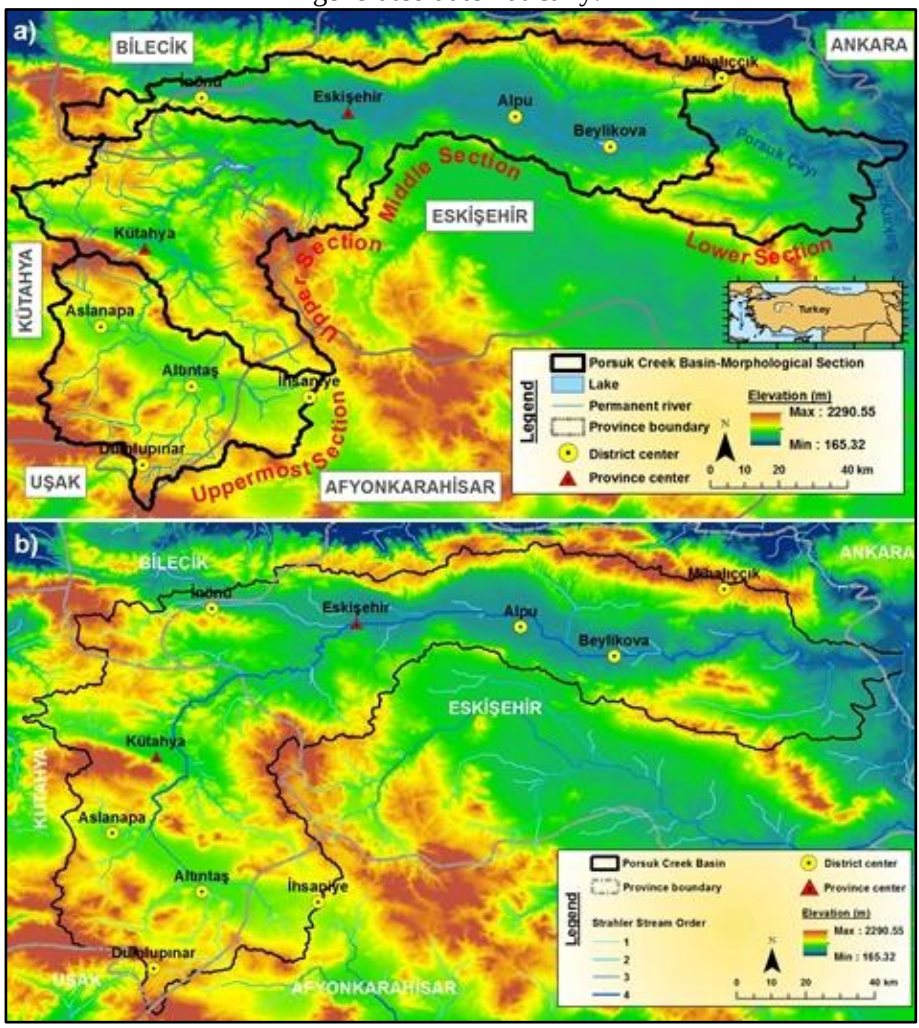
According to the calculations made by manual method from the topographic maps, the area of PCB is 10829,92 km^2 and it has four morphological sections: the Lower Section, Middle Section, Upper Section and Uppermost Section (Figure 2a). The area of the Lower Section, Middle Section, Upper Section and Uppermost Section are ~ 1557,2 km^2, ~ 3628,3 km^2, ~ 3207,8 km^2 and ~ 2436,1 km^2, respectively. According to calculations are performed automatically via DEM, the area of PCB is 10830,25 km^2 (Figure 2b).

355,1 km^2 of the PCB is located within the borders of Bilecik province and Göynücek, Düzağaç, Ketenlik and Yeşilçukurca villages is the residential areas in basin. Approximately 489,6 km^2 of the basin is located within the borders of Afyonkarahisar province and it includes 29 village areas administratively. 19 of them (414,8 km^2) are within the boundaries of the basin together with the settlement area. These are: Anıtkaya, Aşağıtandır, Başkimse, Bayramgazi, Cumalı, Hacıbeyli, İhsaniye, Kadımürsel, Karacaahmet, Muratlar, Olucak, Orhanlı, Osmanköy, Saadet, Susuzosmaniye, Üçlerkayası, Yenice and Yiğitpınarı villages. In administrative meaning the İhsaniye district of Afyonkarahisar province is located in the boundaries of the PCB and constitutes the drainage divide of Uppermost Section.

The general geographical character of the area not included in the basin is as follows: This area contains Altıntaş Plain at the Uppermost Section of the PCB. The area has an area of approximately 414 km^2. The area lies on the between 800 and 900 m elevation and has a flat and near-flat morphology. In terms of land use capability, Class II is common and the most common primary *land use/land cover type* is made up of non-irrigated arable land. There are settlement areas in the region, such as Kütahya/Altıntaş/Aydınlar, Çakırsaz and Erenköy villages and Afyonkarahisar / İhsaniye district with Anıtkaya, Cumalı, Erenler, Hacıbeyli, Karacaahmet, Muratlar, Olucak,

Osmanköy, Susuzosmaniye and Yenice villages. The total population of all the villages in 2016 is 9819.

Figure 2: (a) PCB boundary generated manually and (b) PCB boundary generated automatically.



Discussion and Conclusion

The first stage of hydrological analysis (determination of groundwater potential and stream order, flow direction, flow accumulation analysis, etc.) and morphometric analyzes (size, length, shape, asymmetry, slope, etc.) constitute determination of drainage basins. Incorrect detection or rough

definition of the drainage basin negatively affects both the results of hydrologic analysis and morphometric analysis and the characteristics of the layers such as land cover, land use, geology, geomorphology, lithology, soil and vegetation that are used in hydrological analysis. Such a situation has been observed in the PCB which is a sub-basin of the Sakarya River Basin in Turkey.

It is suggested in the studies related to the PCB that the basin generally contain Eskişehir and Kütahya province center and seven district centers of these provinces and some parts which are within the boundaries of Ankara, Uşak and Afyonkarahisar province (Öztürk, 2007; Çetin et al., 2011; Efelerli, 2008, Tanık et al., 2005, Bakış, etc., 2008, 2011, Göncü, 2011, General Directorate of State Hydraulic Works, 2012). The draft project report prepared by TUBİTAK MAM Environmental Institute (2013) has similar statements. However, this report does not mention that some parts of the Uşak province are located in the PCB. Location maps used in all of the studies mentioned are maps in similar characteristics. In some of these maps, some areas of Afyonkarahisar and Bilecik provinces area not included in the basin and the borders are substantially smoothed. In short, geographic location information is not consistent with location maps and contains deficiencies in it. This is the main point of the PCB boundary problem.

The geographical location of the PCB is not included in the Bilecik and Afyonkarahisar / İhsaniye district centers (Tanık et al., 2005, Öztürk, 2007, Arslan, 2008, Bakış et al., 2008, Büyükerşen and Efelerli, 2008, Bakış et al., 2011, Çetin et al., 2011; DSİ, 2012, TÜBITAK MAM, 2013, Bayazıt, 2014, Şimşek, 2014, Tekkanat and Sarış, 2015); by contrast, in this study were found that PCB contains a part of the Bilecik province and Afyonkarahisar/ İhsaniye district center. In the PCB geographical location maps that most of the Afyonkarahisar province is not included in the drainage basin (Kutlu et al., 2004, Muhammetoğlu et al., 2005, Arslan, 2008, Bakış et al., 2008, Büyükerşen and Efelerli, 2008, Altın et al., 2009, Arslan, 2009; Bakış et al., 2011; Çetin et al., 2011; Köse et al., 2012; Şimşek, 2014), this area that is composed of mostly non-irrigated arable land which is not included in the drainage basin was calculated as ~ 414 km^2 (~ 58000 football fields). This loss of data is great and important. This state is mainly due to the difficulty experienced in passing the boundary of the wide plain in this area where the Altıntaş Plain is located in the manual drawings made on topographic maps. It is a very vexing and difficult to pass the basin boundary through the low flat land in manual drawings. The basin boundary, drainage divide, becomes largely unclear in the soluble rocks cover large areas, the arid regions and the marshy areas. In other words, user-defined procedures are required to

correctly identify and analyze some critical topographic structures which can be found in complex areas where drainage basin and morphological sections extracted from topographic maps manually or semi-automatically. On the other hand, there is no way of deducing from morphology of the terrain in the determination process of the drainage basin using a computer program. However, computer algorithms used in the automatic delineation of drainage basin in which the DEM data is used, DEM type and quality affect accuracy of the results. Under any circumstances, it is preferred delineation of drainage basin using GIS and DEM due to improved accuracy, less duplication, easier map storage, flexibility, simplicity in data sharing, flexibility and data sharing, timeliness, greater efficiency and higher product complexity (Fattah and Yüce, 2015) to manual techniques. Today, drainage basins can be extracted accurately and easily thanks to advanced computer software (such as ArcGIS and QGIS) and DEMs (like DEMs produced by SRTM, Aster, Ikonos, Spot 5, Terra SAR, Terra ASAR, LIDAR) produced by remote sensing technology can be removed in a certain way.

In some of the above-mentioned studies, some of the areas in the Uppermost Section of the PCB are not included in the drainage basin and some deficiencies were found in the geographical location information. Therefore, the drainage basin and the morphological sections are described. The drainage basin was re-created and mapped using topographic maps and DEM. According to the manual based calculation, the area of the PCB is 10829,92 km^2; 10830,25 km^2 according to the DEM based calculation. Considering the important thresholds, the PCB is divided into four sections (Lower, Middle, Upper and Uppermost) in a morphological sense. The PCB includes the Eskişehir and Kütahya provincial centers, the eight district centers (Alpu, Beylikova, Mihalıççık, İnönü, Aslanapa, Altıntaş, İhsaniye and Dumlupınar) and Ankara, Bilecik, Uşak and Afyonkarahisar provinces. It has been pointed out that a large area is not included in the study area, especially at the Uppermost Section of the basin. For this reason, the study results are important in terms of water resources management, land cover / land use planning in the strict sense; integrated river basin management in a broad sense.

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