



Research potential of doctoral studies on environmental sciences and engineering

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Received 22 December 2009; Accepted 22 March 2010

ABSTRACT

The paper evaluates the scientific merit of doctoral studies on environmental sciences and technology, involving completed doctoral studies in Turkey between 2000–2007, as a case study. The investigation revealed 446 scientific papers derived from 170 completed doctoral studies. This level represented 22% of the total number of publications at departments with graduate programs in this field. 42 of the completed studies (25%) did not produce published papers other than the compulsory doctoral thesis. These publications received 2766 citations, corresponding to 6.2 citations per publication; 65 of 170 doctoral studies completed (38%) had no record of any citation, indicating that aside from 42 doctoral theses which did not produce any publications, results of 22 doctoral studies were published but received no citations. Impact factors of selected journals for publication varied within a wide range of 0.429 to 3.894 with an average value of 1.65, based on 2007 impact factor records.

Keywords: Doctoral studies; Scientific publications; Citations; Impact factor; Graduate education; Environmental sciences and engineering

1. Introduction

Doctoral studies are commonly considered as the main driving force for scientific productivity in academic institutions. A doctoral study essentially involves research training; it is designed to provide a comprehensive understanding of the theoretical and methodological bases for acquiring and generating knowledge. This way, doctoral studies create the ability to conduct independent research to deal with a research question, to choose the proper method and to evaluate the results [1]. Therefore, original research is the integral component

of a doctoral study where the doctoral candidate is provided with adequate time and means for conducting an individual study in order to develop and test personal research skills [2]. In this context, the essential requirements of a doctoral program is often a thesis which defines and demonstrates the significant and original contribution of the particular study conducted [3,4].

These are evaluated and the doctoral degree is awarded in recognition of related research findings that are—at least in principle—publishable in a peer-reviewed journal. In other words, publishing a doctoral study in a peer-reviewed journal ensures objective quality recognition of the scientific work performed. Nowadays most doctoral programs recommend the students to

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publish articles derived from their study. This is also an incentive for supervisors for encouraging doctoral candidates to focus on strong research subjects, which can readily be recognized by the international scientific community.

There may be a long list of factors to be considered for evaluating the scientific merit of doctoral studies. Dundar and Lewis [5] provided an excellent review of different determinants of the assessment of research productivity. Such evaluations however run the risk of dealing with too many data which do not necessarily generate enough information. They generally lack “outcome definition” and miss the “leading indicators”.

In this context, this study was carried out with a clearly defined scope, limiting itself to the evaluation of the scientific potential of doctoral studies conducted in Turkey on *environmental sciences and technology*, using only worldwide accessible bibliometric—numerical—indicators, namely, papers published in peer-reviewed journals, citations received to these papers and the impact factors of the journals selected for publications. The assessment was made with the understanding that the selected leading indicators may always be supplemented in the future with additional parameters provided that the newly introduced data are sufficient and relate well with the adopted evaluation process.

2. Materials and methods

2.1. Methodology

The paper essentially evaluated completed doctoral studies in the field of environmental sciences and technology during eight years between 2000 and 2007. For this purpose, available records and faculty resources of academic and research institutions offering doctoral degree in the field were investigated. The preliminary phase of the investigation was based on three major parameters, namely, (i) institutions; (ii) faculty members, and (iii) completed doctoral work. These parameters were first used to identify distribution of completed doctoral work with time and also among different academic institutions. They also served for assessing the respective load and active involvement of faculty members in doctoral studies in each institution.

In the second phase, the research value of completed doctoral theses was evaluated using three major indicators (i) number of published research papers; (ii) citations received to these papers, and (iii) impact factors of journals, where these papers were published. The number of papers published by the candidates during the PhD education is no doubt be taken as an objective numerical indicator representing the scientific merit and productivity of the doctoral work. The number of citations made to a paper is a significant indicator to show how

original and useful the presented work is regarded and how well it is marked in the scientific society. Another important factor that was taken into consideration for determining the quality of the doctoral work was the impact factor. This parameter is a measure of the frequency with which the *average article* in a journal has been cited in a particular year. The impact factor is used to evaluate the relative importance of the selected journal in general and in its particular scientific field.

These indicators were then used in different ways and combinations for the evaluation of significant parameters. (i) publications per doctoral work; (ii) publications per supervisor; (iii) citations to a doctoral study; (iv) citations received by the supervisor; (v) ratio of publications and citations to total corresponding number for each institution, etc. These parameters were elaborated in the following sections.

2.2. Materials

Statistical data provided by The Council of Higher Education (YOK) was used for determining the number of faculty members of the universities and environmental engineering departments in these universities.

As the first step of the evaluation process, theses in the field of environmental engineering completed between 2000 and 2007 were collected using the theses database of YOK [6]. For this purpose doctoral theses in the field of environmental sciences and engineering were scanned and analyzed.

The bibliometric parameters used as major indicators in this study, namely, number of published papers, number of citations to these papers, and the impact factors of the journals, where the papers were published, were assessed using the *ISI Web of Knowledge* (<http://www.isiknowledge.com>) under *Web of Science* general search [7]. This way, research publications were limited to *SCI papers*; the most widely used indexing system that sets an objective and standard basis for comparative evaluation. Citations received were also similarly limited only with those received from other papers published in SCI indexed journals to SCI papers.

Papers published in the same subject area as the doctoral theses conducted in the Environmental Engineering Departments of Turkish universities between 2000 and 2007 were collected, in order to determine *the number of papers*, the first indicator used in this study. In order to make a comprehensive evaluation of the productivity of doctoral studies, papers published in research subjects other than the PhD thesis subject area, were also collected, in a way to explore and reflect the versatility of the PhD education.

Citations of papers published from theses completed between the years 2000 and 2007 at Environmental

Engineering Departments were determined and the data collected was used as a parameter in the determination of the productivity of PhD education. The cited reference search engine provided by *ISI Web of Knowledge* was used as a tool for determining the number of citations for papers published by doctoral candidates. *Impact factors* of journals publishing related research papers were determined using the same tool.

3. Results and evaluation

3.1. General context

The size and the structure of the Turkish higher education system have greatly expanded in the last 25–30 year. This change was mainly due to a parallel, exceedingly increasing demand. In this period, the number of applications for higher education increased by a factor of four. However, the increase in the number of available places in higher education institutions was approximately tenfold. In fact, student enrolment increased from 237,369 in 1980–1981 to 2,342,898 in 2005–2006 [8]. This way, the higher education in Turkey became the sixteenth largest in the world and the fifth largest in Europe [9]. The system now involves a total of 132 institutions with 94 state universities and 38 private, so called *foundation* universities. As shown in Table 1, 39 of these institutions are newly established, starting their academic programs after 2006.

Only 36 universities, representing 27% of total number of 132, are structured to offer undergraduate and graduate programs in *Environmental Sciences and Engineering* by 2008 [10]. As two departments are not currently organized to start education, the effective number of programs is 34. This ratio is substantially lower for private universities, with only two institutions (5%) having environmental engineering programs. As indicated in

Table 1, a total of 21 institutions offer graduate education with doctoral programs in the field of environmental science and engineering. Three of these institutions, namely *Bogazici University*, *Hacettepe University* and *Gebze Institute of Technology*, only offer graduate programs.

As of 2008, the higher education system in Turkey employs a total of 38,435 full time faculty members, with 13,494 full professors, 6,867 associate professors and 18,074 assistant professors [10]. The number of faculty members working in the field of environmental sciences and engineering is only 356, representing 0.9% of the total. The number of faculty members associated with the 20 institutions offering graduate programs in environmental sciences and engineering is 270. The ratio of faculty in this field to total faculty members is given in Table 2. *Istanbul Technical University* has the highest ratio (3.49%) in the field of environmental science and engineering. Although 21 institutions offer graduate programs in environmental sciences and engineering, *Gebze Institute of Technology* is not taken into consideration for further evaluation since there is no PhD students graduated yet from this institute.

Based on the data, graduate programs in environmental sciences provide an average of 13.5 faculty member/institution. As shown in Table 2, the top three universities account for 82 faculty members or 30% of the total, namely *Istanbul Technical University*, *Dokuz Eylul University* and *Atatürk University* with 39, 23 and 20 faculty members, respectively. When top three universities are excluded, the average number of faculty members drops down to 11 per institution. The same ratio is calculated as 6.1 for universities only offering undergraduate programs, a substantially lower level indicating that graduate programs appear to be the main driving force for the recruitment of academic staff.

3.2. Doctoral theses in environmental sciences and engineering

A total number of 170 doctoral theses were completed in environmental sciences and engineering in eight years between 2000 and 2007 (inclusive). According to the database provided by *The Council of Higher Education* [6] this value is to be compared with 8,479 theses in the field of science and technology and a total number of 20,083 theses in Turkey within the same period. The doctoral studies accomplished in environmental sciences and engineering correspond to an average of 21.2 doctoral theses/year and to 1.06 doctoral theses/institution/year. The yearly distribution of the doctoral work, as plotted in Fig. 1, indicates that around 50% of the studies were completed in the last three years, with almost three times as many theses in 2007 as in 2000. Environmental sciences and engineering cover a large spectrum of different research fields. Accordingly doctoral studies were

Table 1
Higher education institutions offering programs on environmental sciences and engineering

Institution	State	Private	Total
Total	94	38	132
Before 2006	68	25	93
Started after 2006	26	13	39
<i>Environmental Sciences and Engineering</i>			
Total	34	2	36
Only undergraduate	14	2	16
Before 2006	29	1	30
Started after 2006	3	1	4
To be started	2	0	2
<i>Graduate Programs</i>			
Total (with undergraduate)	21	0	21
Only graduate	3	0	3

Table 2

Distribution of faculty members among institutions offering graduate programs in environmental sciences and engineering [10]

Higher education institution	Number of faculty members		
	Environmental science and engineering	Total	Ratio (%)
Istanbul Technical University (ITU)	39	1118	3.49
Dokuz Eylül University	23	2508	0.92
Atatürk University	20	1122	1.78
Yıldız Technical University	16	582	2.75
Boğaziçi University	13	414	3.14
Anadolu University	13	645	2.02
Ondokuz Mayıs University	13	731	1.78
Istanbul University	13	894	1.45
Sakarya University	12	547	2.19
Süleyman Demirel University	12	683	1.76
Marmara University	12	1302	0.92
Middle East Technical University	11	728	1.51
Selçuk University	11	1159	0.95
Mersin University	10	497	2.01
Fırat University	10	682	1.47
Kocaeli University	10	687	1.46
Uludağ University	10	753	1.33
Çukurova University	9	764	1.18
Cumhuriyet University	8	420	1.90
Hacettepe University	5	1388	0.36
Total/Average	270	17624	1.53

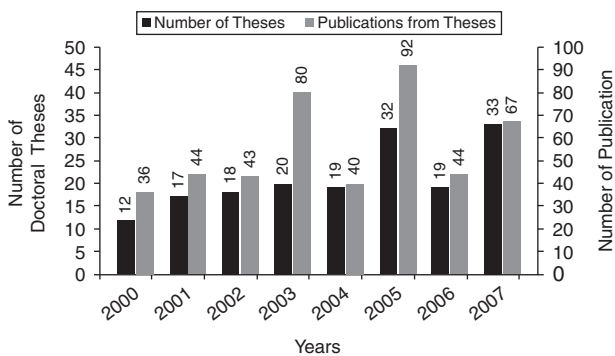


Fig. 1. The yearly distribution of completed doctoral theses and related scientific publications.

conducted in a wide range of 20 different areas varying from *biodegradation* to *ecological impact assessment*.

The distribution of completed doctoral theses among different academic institutions is plotted in Fig. 2. As given in this Figure, the top three universities are *Istanbul Technical University* with 34 theses, *Dokuz Eylül University*, with 24 theses and *Boğaziçi University*, with 18 theses, accounting together for 76 theses or nearly 45% of the total scientific work. Accordingly, the yearly average number of doctoral theses at these

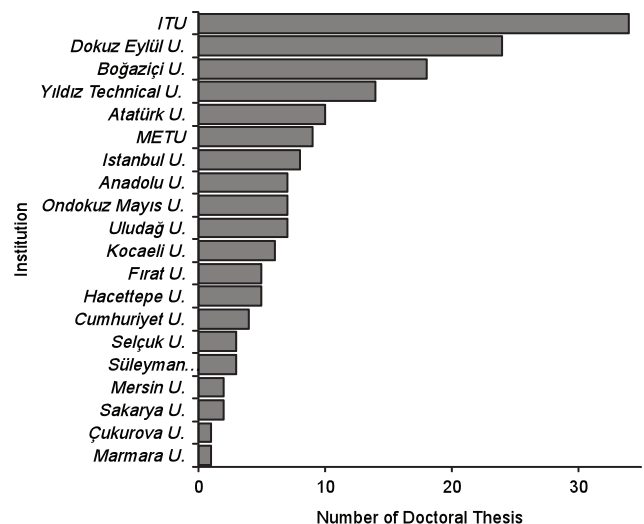


Fig. 2. Distribution of completed doctoral theses among different academic institutions.

universities is 4.25/year for *Istanbul Technical University*, 3.0/year for *Dokuz Eylül University* and 2.25/year for *Boğaziçi University*, so that the same parameter calculated for the remaining 17 institutions drops down to 0.7 doctoral theses/institution/year. The average

Table 3
Characteristic relationships between completed doctoral studies and faculty members

Institution	Number of doctoral theses	Number of faculty members in environmental science and engineering	Faculty members supervising doctoral theses		No of theses per active faculty member	Number of thesis per faculty member
			Number	Active (%)		
Istanbul Technical University (ITU)	34	39	17	44	2.0	0.87
Dokuz Eylül University	24	23	11	48	2.2	1.04
Boğaziçi University	18	13	7	54	2.6	1.38
Yıldız Technical University	14	16	5	31	2.8	0.88
Atatürk University	10	20	5	25	2.0	0.50
Middle East Technical University (METU)	9	11	5	45	1.8	0.82
Istanbul University	8	13	5	38	1.6	0.62
Anadolu University	7	13	5	38	1.4	0.54
Ondokuz Mayıs University	7	13	3	23	2.3	0.54
Uludağ University	7	10	5	50	1.4	0.70
Kocaeli University	6	10	3	30	2.0	0.60
Firat University	5	10	4	40	1.3	0.50
Hacettepe University	5	5	4	80	1.3	1.00
Cumhuriyet University	4	8	4	50	1.0	0.50
Süleyman Demirel University	3	12	1	8	3.0	0.25
Selçuk University	3	11	2	18	1.5	0.27
Sakarya University	2	12	1	8	2.0	0.17
Mersin University	2	10	2	20	1.0	0.20
Marmara University	1	12	1	8	1.0	0.08
Çukurova University	1	9	1	11	1.0	0.11
Total/Average	170	270	91	34	1.8	0.58

value of the same parameter for all institutions is calculated as 0.08 doctoral theses/institution/year.

The characteristic features of the completed doctoral studies with respect to faculty members working at these higher education institutions are presented in detail in Table 3. Significant results may be outlined as follows: (i) on an overall basis, only one third of the faculty members actively supervised completed doctoral studies in the selected period. Active participation varied from 8 to 80% among evaluated institutions. The low level of active participation to gradual work may partly be explained with young faculty members either recently appointed with no graduate load or still supervising on-going studies; (ii) the number of completed theses per active faculty member averaged 1.8 within the selected eight years, while the same parameter was calculated as 0.58 theses based on the total number of faculty members involved; (iii) the doctoral load of active faculty members varied as shown in Fig. 3, where 1 supervisor succeeded in completing 6 doctoral theses in the selected period and 3 supervisors 5 theses each. In this period, 12 active faculty members supervised 53 theses representing more than 30% of the total completed doctoral theses.

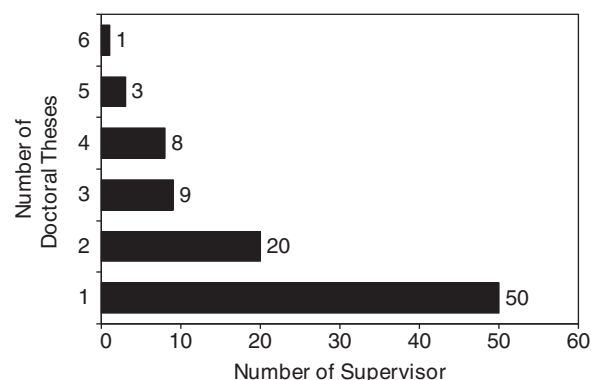


Fig. 3. Distribution of the completed doctoral studies among supervisor.

3.3. Scientific publications from completed doctoral studies

According to *Web of Science* database more than 100,000 scientific publications were addressed to Turkey for the study period. In the same period, a total of 2,193 scientific publications were derived from studies on environmental sciences and engineering, yielding an average of 274 publications/year and 0.102

Table 4
Distribution of scientific papers produced through doctoral studies and students

Institution	Total publication of related departments	Publications from PhD thesis		Publications from other studies		Total publications of doctoral students		Publications of doctoral students/total publication of related departments (%)
		Number	% of Total	Number	% of Total	Number	% of Total	
Istanbul Technical University	359	74	20.6	125	34.8	199	24.7	55.4
Dokuz Eylül University	349	101	28.9	53	15.2	154	19.1	44.1
Middle East Technical University	228	30	13.2	18	7.9	48	6	21.1
Boğaziçi University	142	49	34.5	11	7.7	60	7.5	42.3
Atatürk University	101	37	36.6	12	11.9	49	6.1	48.5
Marmara University	87	3	3.4	13	14.9	16	2	18.4
Yıldız Technical University	83	26	31.3	27	32.5	53	6.6	63.9
Selçuk University	79	7	8.9	7	8.9	14	1.7	17.7
Uludağ University	77	23	29.9	20	26.0	43	5.3	55.8
Süleyman Demirel University	60	4	6.7	13	21.7	17	2.1	28.3
Mersin University	54	5	9.3	4	7.4	9	1.1	16.7
Firat University	53	14	26.4	12	22.6	26	3.2	49.1
Kocaeli University	48	27	56.3	8	16.7	35	4.3	72.9
Çukurova University	47	1	2.1	10	21.3	11	1.4	23.4
Ondokuz Mayıs University	47	8	17.0	4	8.5	12	1.5	25.5
Istanbul University	45	17	37.8	13	28.9	30	3.7	66.7
Sakarya University	45	0	0.0	2	4.4	2	0.2	4.4
Anadolu University	43	11	25.6	2	4.7	13	1.6	30.2
Cumhuriyet University	35	7	20.0	3	8.6	10	1.2	28.6
Hacettepe University	24	2	8.3	2	8.3	4	0.5	16.7
Total/Average	2006	446	20.8	359	15.6	805	5.0	40.1

publications/faculty member/year, which is about threefold of the ratio calculated on an overall basis for the higher education system in Turkey. 2006 of these publications (91%) were made from institutions with graduate programs on environmental sciences and engineering, giving an even higher average value of 0.93 scientific papers/faculty member/year. For environmental engineering departments with only undergraduate programs, this ratio stays at the level of only 0.27 scientific publications/faculty member/year.

In the study period, the number of scientific papers derived from completed doctoral studies was 446. The yearly distribution of these publications is also plotted in Fig. 1. This level represents 22% of the total number of publications at departments with graduate programs in environmental sciences and engineering. As shown in Table 4, top five universities accounted for 291 scientific publications corresponding to 65% of total publications derived from doctoral studies. The table also indicates publications authored by doctoral students but generated from research that is not directly related to doctoral work. This parameter should be evaluated as a significant indicator of the context and depth of doctoral education at different universities. This parameter gives additional 359 publications corresponding to 18% of total publications at institutions with graduate programs. This way, scientific publications involving doctoral studies and students can be calculated as 805, around 40% of the total papers published. *Istanbul Technical University* has the highest ratio of total publications of PhD candidates as 125 publications among a total of 359 papers (35% of total) were published at this institution. This corresponds to around 6% of all publications at institutions with graduate programs, as listed in Table 4.

Another significant approach for the evaluation of scientific productivity is the assessment of scientific publications for individual doctoral studies and supervisors. As shown in Fig. 4, 42 of the 170 doctoral studies completed (25%) did not produce any results to be reported in a scientific publication other than compulsory doctoral thesis. On the other hand, 91 studies generated more than one publication and more than 15 scientific papers were published from two exceptional doctoral studies. Similarly, 15 of the 91 faculty members supervising doctoral studies (17%) did not have any publication derived from related scientific work. A great majority however (69%) published more than one scientific paper. As plotted in Fig. 4b, 11 faculty members published more than 10 scientific papers from supervised doctoral work and the highest achievement goes to one faculty member with 23 papers published based on scientific results derived from supervised doctoral studies.

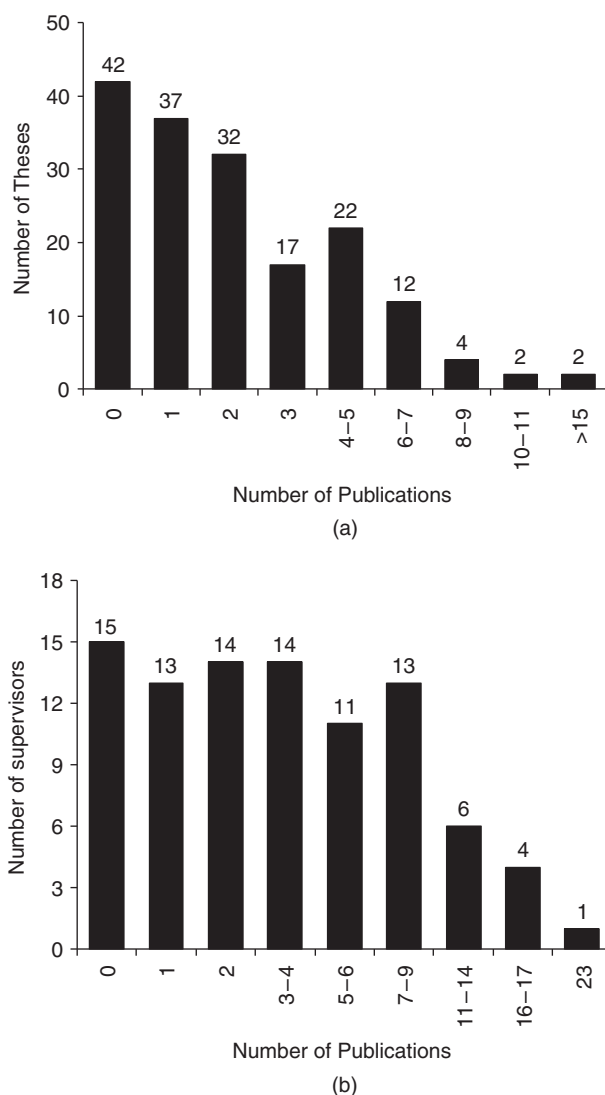


Fig. 4. Distribution of the number of scientific publications among (a) completed doctoral studies; (b) doctoral supervisors.

3.4. Citations received to publications from completed doctoral studies

During the study period, scientific publications from doctoral studies in environmental sciences and engineering field received a total of 2,766 citations corresponding to an average ratio of 6.2 citations/publication. This ratio is compared favorably with 5.5 citations/publication calculated by means of 10,937 citations given to all publications from all institutions with a graduate program in this field.

The distribution of citations among institutions related to doctoral studies is outlined in Table 5. The amount of total citations received by top five universities was 2,283 representing 83% of total citations received by doctoral studies. The table also shows

Table 5
Distribution of citations to scientific papers produced through doctoral studies and students

Institution	Total citations	Citations/ publications	Citations to doctoral publications		Citations to publications from other studies		Citations of doctoral publications/total citations of related departments (%)	Citation/ student	Citations/ publications	
			Number	%	Number	%			Doctoral	Other studies
Dokuz Eylül University	2336	6.7	566	20.5	420	18.3	24.2	23.6	5.6	7.9
Middle East Technical University	1905	8.4	130	4.7	149	6.5	6.8	14.4	4.3	8.3
Istanbul Technical University	1471	4.1	490	17.7	962	41.8	33.3	14.4	6.6	7.7
Bogaziçi University	1100	7.7	786	28.4	103	4.5	71.5	43.7	16	9.4
Atatürk University	796	7.9	311	11.2	102	4.4	39.1	31.1	8.4	8.5
Marmara University	407	4.7	8	0.3	77	3.3	2	8.0	2.7	5.9
Uludağ University	342	4.4	71	2.6	119	5.2	20.8	10.1	3.1	6.0
Ondokuz Mayıs University	323	6.9	12	0.4	9	0.4	3.7	1.7	1.5	2.3
Sakarya University	321	7.1	0	0	9	0.4	0	0.0	0	4.5
Firat University	292	5.5	70	2.5	82	3.6	24	14.0	5	6.8
Çukurova University	268	5.7	3	0.1	52	2.3	1.1	3.0	3	5.2
Yıldız Technical University	248	3.0	83	3	86	3.7	33.5	5.9	3.2	3.2
Mersin University	232	4.3	49	1.8	0	0	21.1	24.5	9.8	0.0
Selçuk University	228	2.9	23	0.8	27	1.2	10.1	7.7	3.3	3.9
Süleyman Demirel University	146	2.4	0	0	32	1.4	0	0.0	0	2.5
Hacettepe University	143	6.0	3	0.1	22	1	2.1	0.6	1.5	11.0
Kocaeli University	127	2.6	99	3.6	20	0.9	78	16.5	3.7	2.5
Cumhuriyet University	105	3.0	13	0.5	4	0.2	12.4	3.3	1.9	1.3
Anadolu University	91	2.1	30	1.1	8	0.3	33	4.3	2.7	4.0
Istanbul University	56	1.2	19	0.7	17	0.7	33.9	2.4	1.1	1.3
Total/Average	10937	5.5	2766		2300		25.3	16.3	6.2	6.4

presence of publications authored by doctoral students, aside from their doctoral studies. These publications from research which were not directly related to doctoral work received additional 2,300 citations.

Average of citations related to doctoral studies of students constitutes more than 25.3% of all citations received by institutions with graduate programs. Considering all publications of doctoral students, the average of citations per a doctoral student was calculated 16.3.

The distribution of citations among individual doctoral studies and supervisors is illustrated in Fig. 5, showing that 65 of 170 completed doctoral studies (38%) have no record of citation. When number of publications and citations were considered together (Fig. 4 and Fig. 5), apart from 42 doctoral theses which did not produce any publications, results of 22 doctoral studies were published but received no citations so far. The Fig. 5a also shows 23 doctoral studies each having more than 30 citations and 5 studies having more than 100 citations. Similarly, 69 of 91 faculty members (76%) received at least one citation to their publications derived from supervised doctoral studies; leaving aside 22 supervisors without any citations. 7 of these with non-cited publications, leaving 15 supervisors without published papers. The data show 6 supervisors with more than 100 citations each and the outstanding performance of 2 supervisors with more than 200 citations (Fig. 5b).

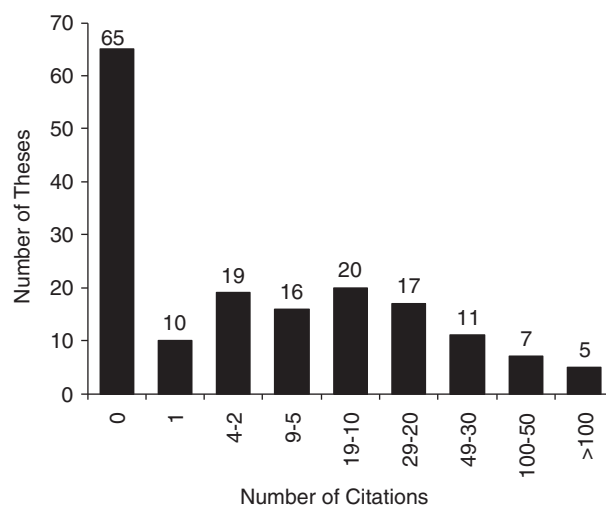
3.5. Impact factors of selected journals for publication

Papers derived from doctoral studies were published in 147 journals. 109 of these journals received only one paper. The remaining 38 journals in which more than one paper published from the scientific results of doctoral theses are listed in Table 6. These journals reflect the wide spectrum of different subjects investigated in these studies. The impact factors of the selected journals varied within a wide range of 0.429 and 3.894 having an average of 1.65 based on 2007 impact factor data [7].

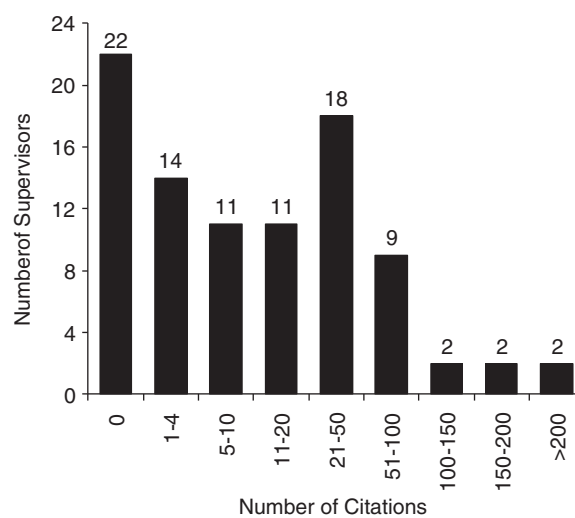
As given in Fig. 6a, 20% of journals selected for publishing papers were characterized with an impact factor higher than 1.0 and 3% of them had an impact factor higher than 3.0. The weighted impact factor for these journals was calculated as 1.65. Similarly, publication-based evaluation indicates that 230 of 446 publications (52%) were published in journals with an impact factor higher than 1.0 and 28 publications with an impact factor higher than 3.0 (Fig. 6b).

4. Conclusions

Data presented and evaluated in the preceding sections offer significant observations that may be summarized as the concluding remarks of the study.



(a)



(b)

Fig. 5. Distribution of the number of citations among (a) completed doctoral studies; (b) doctoral supervisors.

The first observation should relate to the quantitative analysis of doctoral studies completed relative to faculty resources available for this purpose. During the study period a total of 270 faculty members employed in 20 departments offering graduate programs in environmental sciences and engineering could only generate around 21 completed doctoral theses per years, corresponding to average values of 0.08 theses/faculty member/year or 1.06 theses/department/year. In other words, it takes, on the average, close to 13 year for each faculty member to complete a supervised doctoral study, with the net result that the scientific output stays too low compared to potential available. Another closely related parameter is the faculty involvement: only one third of the faculty

Table 6
Impact factors of journals selected for publication of doctoral studies

Journal title	Publications		2005 IF	2007 IF	IF (2007/2005)
	Number	%			
Journal of Hazardous Materials	33	7.4	1.544	2.337	1.51
Fresenius Environmental Bulletin	31	7.0	0.509	0.429	0.84
Water Science and Technology	30	6.7	0.875	1.24	1.42
Process Biochemistry	26	5.8	1.796	2.336	1.30
Journal of Environmental Science and Health Part A-Toxic/Hazardous Substances and Environmental Engineering.	19	4.3	0.786	0.967	1.23
Bioresource Technology	16	3.6	1.863	3.103	1.67
Atmospheric Research	14	3.1	1.481	1.786	1.21
Environmental Technology	14	3.1	0.718	0.735	1.02
Desalination	13	2.9	0.955	0.875	0.92
Enzyme and Microbial Technology	13	2.9	1.705	1.969	1.15
Journal of Chemical Technology and Biotechnology	11	2.5	0.981	1.426	1.45
Chemosphere	10	2.2	2.297	2.739	1.19
Environmental Engineering Science	9	2.0	1.054	0.944	0.90
Environmental Monitoring and Assessment	9	2.0	0.687	0.885	1.29
International Journal of Environment and Pollution	8	1.8	0.327	0.435	1.33
Separation and Purification Technology	8	1.8	1.752	2.142	1.22
Science of The Total Environment	6	1.3	2.224	2.182	0.98
Journal of Membrane Science	6	1.3	2.654	2.432	0.92
Waste Management	6	1.3	1.123	1.338	1.19
Journal of Environmental Engineering-ASCE	5	1.1	0.942	1.174	1.25
Ozone-Science & Engineering	5	1.1	0.495	1.515	3.06
Environmental Science and Pollution Research	4	0.9	1.518	3.894	2.57
Journal of Environmental Management	4	0.9	1.163	1.446	1.24
Chemical Engineering Journal	3	0.7	2.034	1.707	0.84
Dyes and Pigments	3	0.7	1.694	2.796	1.65
Water Air and Soil Pollution	3	0.7	1.258	1.224	0.97
Biodegradation	3	0.7	1.714	2.187	1.28
Biotechnology and Bioengineering	3	0.7	2.483	3.037	1.22
Water Research	3	0.7	3.019	3.427	1.14
Water SA	3	0.7	0.445	1.12	2.52
Applied Microbiology and Biotechnology	2	0.4	2.586	2.475	0.96
Environmental Geology	2	0.4	0.654	0.722	1.10
Environmental Pollution	2	0.4	2.451	3.135	1.28
Environmental Progress	2	0.4	0.878	1	1.14
International Journal of Hydrogen Energy	2	0.4	1.904	2.725	1.43
International Journal of Photoenergy	2	0.4	0.851	0.942	1.11
Marine Pollution Bulletin	2	0.4	1.831	2.334	1.27
Resources Conservation and Recycling	2	0.4	0.786	1.27	1.62

was actively involved in supervising completed doctoral studies. This is an important issue which merits further consideration for appropriate assessment and improvement. One of the obvious reasons is the lack of enrollment despite presently high demand for graduates with doctoral degrees in this field. The faculty involvement aspect may be attributed and explained with relatively young faculty members either with no graduate load or still supervising on-going doctoral work.

Another related and significant observation is the strikingly uneven distribution of doctoral outputs among universities: Nearly 45% of the completed doctoral studies were associated with the top three universities with outstanding reputation in this field. This result underlines the need for improving the faculty resources and the available research infrastructure in most of the newly established institutions to make them similar centers of attraction for high quality doctoral programs.

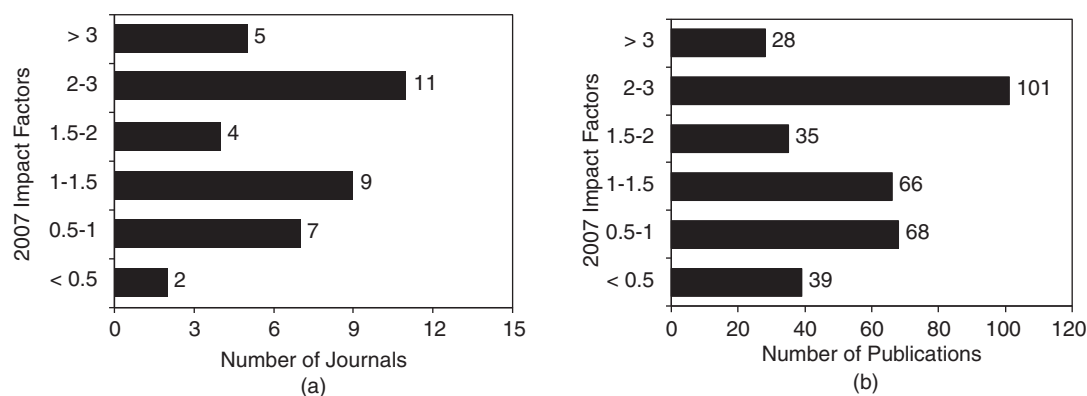


Fig. 6. Distribution of the impact factors of (a) journals; (b) publications in respective journals.

The last observation relates to the relevance of selected numerical indicators, namely the number of published research papers, citations received and the impact factors of the selected journals for assessing the quality and research value of the completed doctoral studies. The presented data provided conclusive data that (i) the indicators were quite significant and provided concrete indications for quality assessment and improvement, and (ii) they complemented each other so that they should best be considered together and not individually. In this context, the completed doctoral work revealed a high research quality with an average of 2.6 publications/thesis and 6.2 citations/publication. These parameters corresponded to more than 20% of the total related outputs at departments with graduate programs in this field. The indicators also provided avenues of future improvement, indicating that 25% of completed doctoral studies did not produce published papers and 13% although published, received no citations. Again top five universities produced 65% of related scientific publications.

The study also provided interesting correlations between size of faculty and the research performance, leading to suggest that up to a critical threshold level, increase in faculty size generates a parallel higher research productivity beyond which a further increase starts having a negative impact, confirming similar observations reported by Dundar and Lewis [5].

It is strongly recommended that conducting similar assessments on the research potential of different

fields, preferentially using similar indicators offering comparative analyses, may help defining reliable objective assessments and take corrective actions for the shortcomings of educational institutions in Turkey and worldwide.

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