

Current status of nanotechnology in Jordan

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Abstract

Purpose – The current status of nanotechnology research and development in Jordan is analyzed. In recent years, Jordanian institutions demonstrated considerable interest in the development and production of nanotechnology. Here the purpose of this paper is to provide detailed information about the status of nanotechnology in Jordan in terms of several factors that influence selectivity in nanotechnology and the number of published peer-reviewed research articles.

Design/methodology/approach – Several factors that influence selectivity in nanotechnology and the number of published peer-reviewed research articles were analyzed. A detailed analysis of the collected data reveals that the number of publications, citations, and patents is highly dependent on the amount of research fund.

Findings – The development in nanotechnology is associated with presence and accessibility of sensitive laboratory equipment. The nanotechnology research output in Jordan is still lower than it should be due to the lack of necessary laboratory infrastructure. This is due to the insufficient funds allocated to scientific research, the restrictive access to available instruments and the bureaucracy of some governmental departments. Compared to some developed countries, Jordan is noticeably behind in developing a nanotechnology system of research and industry. It will take time as well as technical and financial resources in order to achieve an advanced level in the field of nanotechnology in Jordan. Nevertheless, many Jordanian researchers are doing their best and are producing some good research articles.

Research limitations/implications – The many applications to the same approach.

Practical implications – Time and publications' resources.

Social implications – Peer cooperation.

Originality/value – First comprehensive review ever. A base for researchers and decision makers.

Keywords Middle East, Review, Jordan, Nanotechnology

Paper type General review



Introduction

Jordan is an Arab kingdom in the Middle East. It is considered as an economically and politically stable country compared to other states in the region including North Africa. According to the United Institute for Statistics of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Jordanian adult literacy rate projection for the year 2015 is 94.5 percent (UNESCO, 2013). The Jordanian educational system is well-established and the UNESCO ranked Jordan's education system 18th out of 94 nations especially for providing gender equality in education (Global Arab Network). Around 5 percent of Jordan's total government expenditures goes to education (UNESCO Institute for Statistics).

In Jordan, there are two researchers per thousand people, compared to five researchers per thousand for the highest performing countries (Butler, 2006). According to the Global Innovation Index 2011, Jordan is the third most innovative economy in the Middle East.

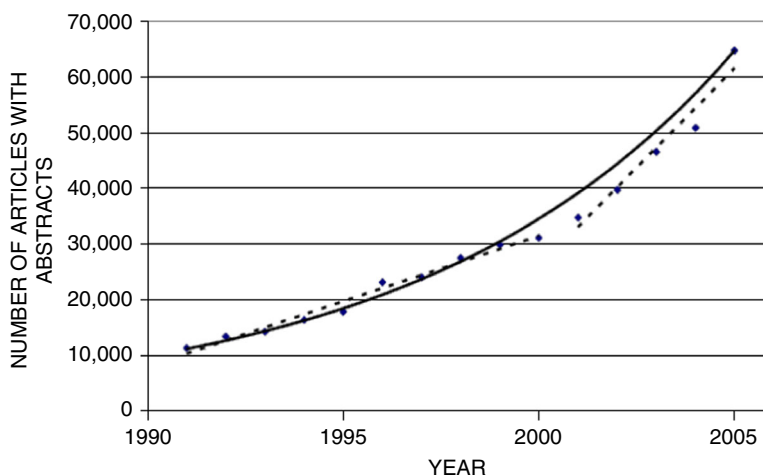
Jordan has 26 universities and 54 community colleges. There are over 200,000 Jordanian students enrolled in universities each year. An additional 20,000 Jordanians pursue higher education abroad primarily in Europe and North America. According to the Webometrics Ranking of World Universities, the top-ranking universities in the country are the University of Jordan (1,348th worldwide), Yarmouk University (1,935th), and the Jordan University of Science & Technology (2,346th) (WEBOMETRICS). Regionally, the University of Jordan is ranked among the top 10 out of 983 Arab Universities in 2014 (WEBOMETRICS). Jordan contribution to the Arabic internet content is more than any other Arab country estimated around 75 percent of all Arabic online content (The International Telecommunication Union (ITU) Report, 2012).

Nanotechnology has great impact on current technological development and is therefore considered to be a key technology of the twenty-first century. Global nanotechnology research article production has exhibited exponential growth over the past decade as shown in Figure 1. Figure 2 shows that the most rapid growth over that period has come from East Asian nations, notably from China and South Korea (Hussein-Al-Ali *et al.*, 2014b).

In recent years, Jordanian institutions demonstrated considerable interest in the development and production of nanotechnology. However, until now, there are not much descriptive details of the current status and development of nanotechnology in Jordan. This paper will provide detailed information about the status of nanotechnology in Jordan in terms of several factors that influence selectivity in nanotechnology and the number of published peer-reviewed research articles. Data were collected using public search engines such as Google Scholar and specialized scientific libraries such as SciFinder. A detailed analysis of the collected data are presented and discussed.

Nanotechnology research article production from Jordan

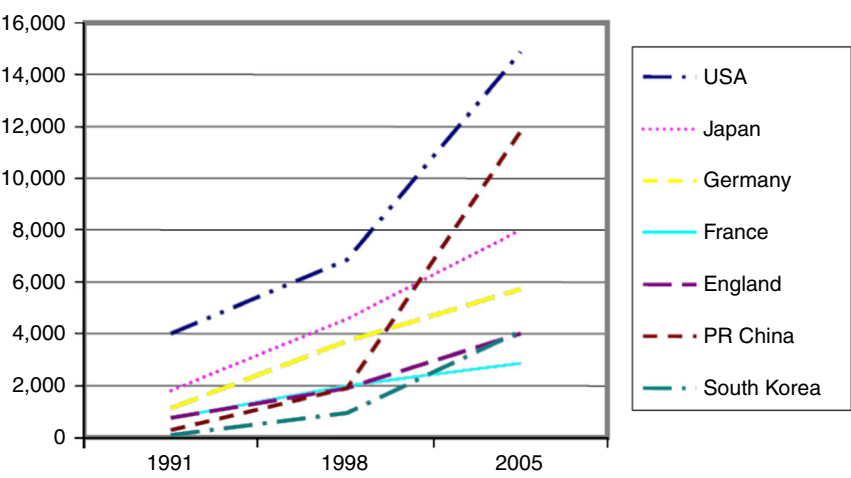
Despite Jordans limited resources and logistics capabilities, nanotechnology research article production in Jordan has exhibited exponential growth in the past few years



Source: Global Nanotechnology Research Production

Figure 1.
Global
nanotechnology
research article
production for the
period (1990-2005)

Figure 2.
Nanotechnology
research article
production by
country for the
period (1990-2005)



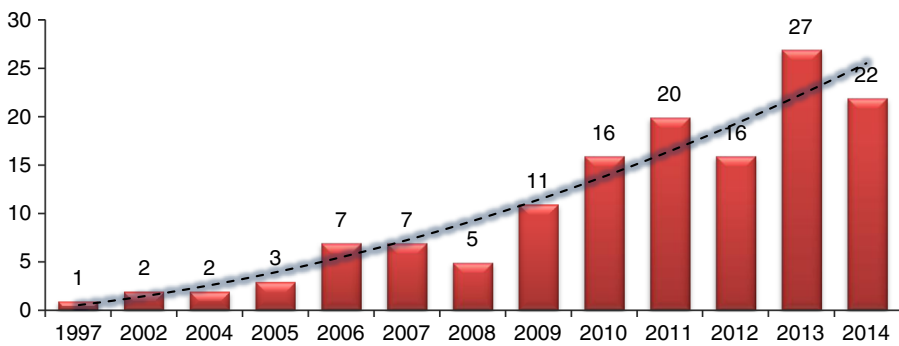
Source: Hussein-Al-Ali *et al.* (2014a, b)

(Table I and Figure 3). Compared to leading countries in the field (China, USA, Japan, and Germany), Jordan exhibits similar exponential growth in the research article production. It is noticeable that there is a modest number of articles reported from Jordan compared to the global number and that the exponential growth in Jordan is

Table I.
Contribution of
nanotechnology
research article
production by
institution

No.	Academic sector	Type if institution	Abb.	No. of articles	Total	
1	Jordan University of Sci. & Tech.	Academic	JUST	51	2	53
2	The University of Jordan	Academic	UJ	36	0	36
3	Balqa Applied University	Academic	BAU	27	3	30
4	Hashmia University	Academic	HU	11	3	14
5	Yarmok University	Academic	YU	6	4	10
6	Al-Isra University	Academic	AIU	4	0	4
7	Royal Scientific Socity	Research	RSS	2	2	4
8	Muta University	Academic	MU	1	1	2
9	National Center of Research	Research	NCRD	1	0	1
10	German Jordan University	Academic	GJU	0	1	1
	Total			139	16	155

Figure 3.
Nanotechnology
research article
production in Jordan
for the period
(1997-2014)



about 15 years behind some leading countries in the field. For example, the growth in research article production in USA started before 1990 (Figure 1), while in Jordan it started around 2005 (Figure 3).

Nanotechnology research interest in Jordan

From the analysis of nanotechnology research article production in Jordan, scientists show more interest in certain fields of nanotechnology. Figure 4 shows that nanomaterials based on composites (Hussein-Al-Ali *et al.*, 2014a, b; Kura *et al.*, 2014; Dorniani *et al.*, 2014; Saad *et al.*, 2004, 2005, 2006a, b, 2007, 2009a, b, c, 2012; Fedotov *et al.*, 2004, 2010; Frantskevich *et al.*, 2008; Saad, 2009; Koltunowicz *et al.*, 2011a, b; Fedotova *et al.*, 2011; Mousa *et al.*, 2013; Koltunowicz *et al.*, 2013, 2014; Kasiuka *et al.*, 2014; Gharaibeh *et al.*, 2010; Albiss *et al.*, 2010a, b, c; Al-Saleha, 2011; Al-Douri *et al.*, 2012; Alsaad *et al.*, 2012; Al-Saleh and Sundararaj, 2012, 2013a, b; Arafa *et al.*, 2012, 2013; Al-Saleh *et al.*, 2013a, b, c, d, e; El Ghanem *et al.*, 2013; Khnouf *et al.*, 2014; Oweis *et al.*, 2014; Zaitoun and Lin, 1997; Abedrabbo *et al.*, 2006; Mubarak *et al.*, 2010; Al-Hussein *et al.*, 2013; Nayfeh, 2010; Sekhaneh and Dahmani, 2014; Alsyouri *et al.*, 2006, 2013; Azadi Motlagh *et al.*, 2010; Bsoul and Mahmood, 2010; Mubarak, 2011; Ruderer *et al.*, 2010; Satarkar *et al.*, 2010, 2015, 2016; Azhdarzadeh *et al.*, 2015; Canonico-May *et al.*, 2016; Dreaden *et al.*, 2012) was the most studied field with more than a third of the total produced research papers. Metallic nanoparticles (Aldwayyan *et al.*, 2013; Al-Rawashdeh *et al.*, 2008, 2009; Rjoub and Al-Othman, 2010; Almasri *et al.*, 2010; Al-Rawashdeh and Azzam, 2011; Obaidat *et al.*, 2011, 2012; Obeidat *et al.*, 2011; Gharaibeh *et al.*, 2010; Aljarrah *et al.*, 2012; Rjoub and Al-Durrah, 2012; Alzoubi and Abu Bidier, 2013; Alqadi *et al.*, 2014; Al-Douri *et al.*, 2014; Masadeh *et al.*, 2015; Awwad *et al.*, 2013, 2014a, b; Elshuraydeh *et al.*, 2008, 2014; Nayfeh *et al.*, 2006; Abuhassan, 2009a, b; Ewe *et al.*, 2009; Hamadneh *et al.*, 2009; Abuhassan and George, 2011a, b; Rawwagah *et al.*, 2012; Hourani and Hamdan, 2013; Boulos *et al.*, 2013; Alkilany *et al.*, 2013, 2014a, b; AlShamaileh *et al.*, 2013; Salem and Awwad, 2013; Hourani and Mahmood, 2014; Suib *et al.*, 2014; Al-Haj *et al.*, 2002) such as: gold and copper nanoparticles came second with around a quarter of the papers. Carbon nanomaterials such as CNT (Al-Khedher *et al.*, 2011, 2012; Khrutchinsky *et al.*, 2011; El-Sheikh *et al.*, 2007a, b, 2008a, b, 2011, 2012; El-Sheikh, 2008; Al-Degs *et al.*, 2009; Fafous and Dawoud, 2012; El-Sheikh and Sweileh, 2011; Fafous *et al.*, 2011; Bsoul *et al.*, 2012; Al-Saleh *et al.*, 2013a, b, c, d, e), silicon nanoparticles (SiNP) (Belomoin *et al.*, 2002; Abuhassan and Nayfeh, 2005, 2007; Abuhassan *et al.*, 2005; Nayfeh and Abuhassan, 2006; Nayfeh *et al.*, 2006; Nielsen *et al.*, 2007; Abuhassan, 2009a, b, 2010; Rogozhina *et al.*, 2011), polymeric nanomaterials (Al Robaidia *et al.*, 2011; Faresa and Othman, 2009;

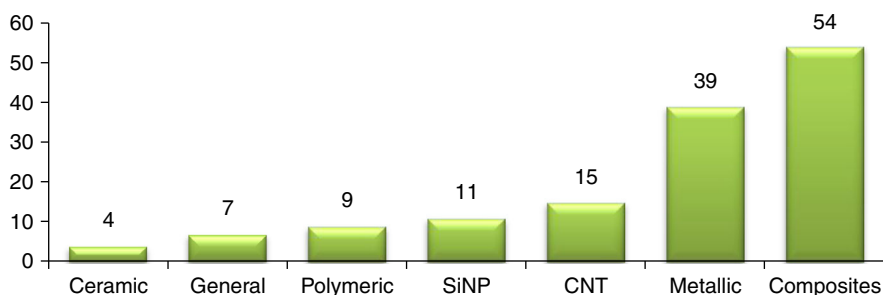


Figure 4.
Number of
nanotechnology
research articles in
Jordan according to
fields of interest

Irshidat *et al.*, 2011; Fares and Al-Shboul, 2012; Al-Saleh *et al.*, 2013a, b, c, d, e; Al-Saleh and Sundararaj, 2013a, b; Athamneh *et al.*, 2013; Abu-Dahab *et al.*, 2013; Abdel Hamid *et al.*, 2011), and ceramic nanoparticles (Albashaireh *et al.*, 2010; Hamadneh *et al.*, 2010, 2013; Hamdy, 2012) caught some interest, as well. Fabrication and general nanoparticles studies were also noticed (Fink *et al.*, 2007; Rjoub and Al-Ajlouni, 2011; Obaidat and Albiss, 2011; Jaradat, 2013; Al-Nimr and Al-Dafaie, 2014; Sakhtianchia *et al.*, 2013; Odeh *et al.*, 2014).

This analysis indicated that researchers in Jordan tend to be inclined to studying nanomaterials that have industrial applications and keep away from the less funded basic research.

Contribution by institution

In Jordan, the majority of nanotechnology research article production comes from academic sectors as shown in Table I. Public institutions account for about 97 percent of the total production while private institutions contribute to the rest. The University of Jordan (UJ) and Jordan University of Science and Technology (JUST) are the most active universities in the field of nanotechnology with more than half the total production. Figure 5 displays the total number of research article in the academic and research institutions in Jordan.

Nanotechnology research institutes in Jordan

In 2010, the Nanotechnology Center at JUST is established as a multidisciplinary research and development incubator with the aim of creating an environment that promotes creativity and innovation in nanotechnology-related disciplines. Since its start, the center produced over 40 research articles.

In 2009, The Higher Council for Science and Technology took the decision to establish the National Nanotechnology Center of Jordan. The center commenced its functions officially in early February 2010. The center aims at building the scientific capacity in the field of nanotechnology in Jordan through programming and coordinating nationwide scientific research and development activities in the field providing the necessary financial support. Moreover, it provides great networking among Jordanian researchers with their counterparts/collaborators abroad.

Hamdi Mango Center for Scientific Research was founded at the University of Jordan in 1999. The center funds selected scientific research projects in the nanotechnology fields. It provides a decent infrastructure for laboratory equipment and space.

The Atomic Energy Commission is building an electron accelerator project (SESAME Synchrotron) in the Salt city. It is used to diagnose the characteristics of optical, electronic, and molecular structure of the nanomaterials used in various fields.

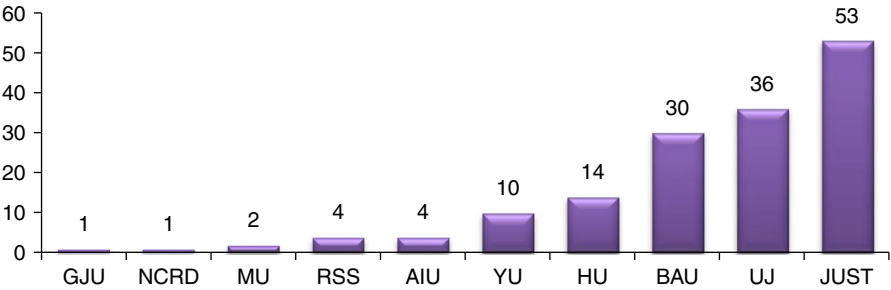


Figure 5.
The total number of research articles in the academic and research institutions in Jordan

Conferences and workshops in Jordan

Jordan institutions organized a number of conferences related to nanotechnology at higher education level. Here, we will be listing the most important events as examples despite the presence of many more at different levels of organization. The International Conference on Nanotechnology is taking place in March 2015 in Amman, Jordan. The Seventh Jordan International NanoTechnology and Engineering Conference took place in November 2014 in Amman, Jordan. The Fourth International Conference on Biomedical Engineering, Electronics, and Nanotechnology was held in June 2014 in Amman, Jordan. The National Science Foundation has sponsored a conference on nanotechnology that was held in the University of Jordan in 2008. The Nanostructured Advanced Materials Workshop took place at the University of Jordan in November 2008. The International Conference on Materials in Jordan took place at the German-Jordanian University in March 2009.

Industry contribution to nanomaterials in Jordan

There are some industries in Jordan that deal with nanomaterials. Nanomaterials are primary components for the manufacture of paints (calcium carbonate, kaolin, and bentonite) as well as the pharmaceutical industry and cosmetics. Generally speaking, we have not come across concrete and reliable statistical information regarding the industrial facilities that use nanomaterials in their industries. There are many factors affecting the development in nanomaterials in the Jordanian industry including fund and the way it runs in Jordan. For example, raw materials containing ultrafine particles are much more expensive than the usual raw materials preferred by Jordanian factories. The need to implement the use of nano-based raw materials is not yet well-established.

International collaboration

Recently, a strategic partnership was declared between the Higher Council for Science and Technology, the National Center for Research and Development, and Yarmouk University from the Jordanian side with the National Association of Nanotechnology of Russia. A five-year plan is set to start a long-term strategic partnership between the three parties, for collaboration in the nanoscience and nanotechnology fields. The aim of this agreement is to encourage the exchange of scientific and technical information as well as professional advice performing some joint activities in research and development. Moreover, it will enhance the accomplishment of joint testing and manufacturing in the area of nanotechnology by researchers from both sides. The parties aim to create nanotechnology centers at universities equipped with specialized laboratories with trained staff and postgraduate researchers (Table II).

Institute	No. of papers	Institute	No. of papers
National Center (NCRD)	1	Al-Zaytoonah University (ZU)	6
Petra University (PU)	1	German Jordan University (GJU)	7
Al-Isra University (AIU)	2	Yarmouk University (YU)	7
Royal Society (RSS)	4	Applied Science University (ASU)	10
Mutah University (MU)	5	Al Balqa Applied University (BAU)	21
Philadelphia University (PhU)	5	University of Jordan (UJ)	41
Hashemite University (HU)	6	Jordan University of Science and Technology (JUST)	61

Table II.
Research article
production from
Jordan Universities
from international
collaboration

Conclusions

The number of publications, citations, and patents is highly dependent on the amount of research fund. The development in nanotechnology is associated with presence and accessibility of some sensitive instruments such as FEI, AFM, XRD, XRF, X-ray single crystal and electron accelerator. Despite the high ambition of many scientists/researchers in Jordan, the nanotechnology research output in Jordan is still lower than it should be due to the lack of the laboratories infrastructure. This is due to the insufficient funds allocated to scientific research, the restrictive access to available instruments and the bureaucracy of some government departments.

If we compare Jordan to some developed countries, it is still in the crawling phases of developing a nanotechnology system of research and industry. It takes time and infrastructure as well as technical and financial resources in order to achieve an advanced level in the field of nanotechnology in Jordan. Nevertheless, many Jordanian researchers are doing their best and are producing some good research articles.

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